Final Report

Groundwater Assessment

Onsite Wastewater Systems Assessment Program

Lowcountry Sites, Charleston County, South Carolina

Prepared for:

South Carolina Department of Health and Environmental Control
Office of Environmental Quality Control
Bureau of Water
Non-Point Source Program (S.319)

SCDHEC Contract Number J04-N058-MJ

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Signature Page

This Groundwater Assessment Report has been prepared by the North Wind and GEEL for the South Carolina Department of Health and Environmental Control (SCDHEC), Office of Environmental Quality Control, Bureau of Water, Non-Point Source Program (S.319). This Groundwater Assessment was performed in accordance with the Field Operations Work Plan and associated quality management and control provisions intended to guide this work, and previously submitted to, and approved by SCDHEC. We further attest, to the best of our knowledge, that the information provided in this report has been prepared in accordance with generally accepted agency and industry standards, that the information presented is complete and accurate, and that the work has been performed in a manner consistent with all applicable regulations.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

A brief Appendix, Understanding JMP™ Statistical Graphical Results, is attached to this report. This appendix provides the reader with guidance on the interpretation of the graphical output from the JMP™ Statistical Software employed in data analysis.

LIST OF OTHER APPENDICES

For Sites A-T, the following information is provided, as a separate project file, delivered to SCDHEC as a companion reference file. These materials are not incorporated into this formal project report. Reference copies of these materials will be retained by SCDHEC, Bureau of Water, and North Wind.

Supplemental Information Category

Field Investigation

1. SCDHEC Form 1903 – Water Well Records
2. Field Data Calculations Sheet – Potentiometric Conditions
3. Field Groundwater Sample Data Sheet
4. Field Meter Calibration Form
5. Site Sketch
6. Field Notes

Analytical Results

7. Certificate of Analysis (GEEL Analytical Results)
8. QC Summary
9. Chain of Custody – GEEL Samples
10. GEEL Sample Receipt & Review Form
11. GEEL PM Data Package Review
12. Report of Bacteriological Analyses (Trident Analytical Results)
13. Chain of Custody – Trident Samples
14. Trident CoC Discrepancy Report

Site Access & Permit Documents

15. Application for Individual Sewage Treatment and Disposal System Permit
16. Permit to Construct Individual Sewage Treatment and Disposal System
17. Right of Entry

LIST OF ACRONYMS

ANOVA	Analysis of Variance
BEH	Bureau of Environmental Health (SCDHEC)
BGS	Below Ground Surface
BOW	Bureau of Water (SCDHEC)
DP	Direct Push (sample)
DQO	Data Quality Objectives
FC	Fecal Coliform
FOWP	Field Operations Work Plan
GA	Groundwater Assessment
GAR	Groundwater Assessment Report
GEEL	General Engineering and Environmental, LLC
LTAR	Long-Term Acceptance Rate
MCL	Maximum Contaminant Level
msl	Mean Sea Level
NO3-NO2	Nitrate-Nitrite Nitrogen
NRCS	Natural Resources Conservation Service
OSWS	Onsite Wastewater System
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
SCDHEC	South Carolina Department of Health and Environmental Control
SCS	Soil Conservation Service
SHGW	Seasonal High Groundwater
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Top of Casing
TP	Total Phosphorus
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

FINAL REPORT

GROUNDWATER ASSESSMENT

ONSITE WASTEWATER SYSTEMS ASSESSMENT PROGRAM

LOWCOUNTRY SITES, CHARLESTON COUNTY, SOUTH CAROLINA

1.0 INTRODUCTION

The purpose of this Groundwater Assessment Report (GAR) is to present the results of a targeted groundwater assessment conducted with respect to the performance of Onsite Wastewater Systems (OSWS) in the coastal region of South Carolina during spring 2005 – winter 2006. This study was conducted by North Wind, Inc. (formerly Pinnacle Consulting Group, Inc.) and General Engineering and Environmental, LLC, under contract to the South Carolina Department of Health and Environmental Control (SCDHEC), Bureau of Water (BOW), Non-Point Source Program (S.319). This work was performed under SCDHEC Contract Number J04-N058-MJ, and funded by S.319 resources.

This GAR presents the results of work conducted at twenty (20) sites located in the lowcountry region of the state, all in Charleston County. These sites represent typical single-family OSWS settings, all located in sandy soils with shallow seasonal groundwater conditions. All of the OSWSs monitored in this study were properly permitted and constructed within the previous roughly five to fifteen years in accordance with state regulations governing OSWS practice in South Carolina (SCDHEC R.61-56). Hence, these systems reflect typical OSWS practices employed under the local conditions.

The core purpose of this assessment was to examine the performance of these typical, properly permitted OSWSs with respect to their effects on shallow groundwater resources. The approach

employed in this groundwater assessment (GA) was basically to collect intensive one-day "snapshot" information with regard to groundwater quality adjacent to and downgradient from the OSWSs. Project field operations were designed that allowed for minimal impact, unobtrusive sampling activities performed on private properties, that would assess typical operating conditions and groundwater effects associated with these systems. This study was carried out over the period March 2005 – January 2006, and hence reflects the range of conditions that may be expected from these systems over the course of a typical year. Numerous systems were monitored during the spring and winter periods during which the water table is shallowest; other systems were monitored during summer.

2.0 BACKGROUND INFORMATION

2.1 STUDY SETTING

All of the sites selected for assessment are located in the lowcountry region of South Carolina, all in Charleston County. The locations of the twenty sites studied are shown on Figure 1. The sites sampled range from 3 to 17 miles from the coast, and all sites are at elevations of ranging from approximately 7 ft to 43 ft msl. Many of the sites are adjacent to, or proximal to surface waters, which are locally affected by tidal variations.

2.2 SITE AND SYSTEM CRITERIA

Only those OSWSs installed in predominantly sandy soils, with high seasonal groundwater conditions were considered as candidates for sampling. This scenario was considered to present a worst case in terms of potential impacts to groundwater quality from ordinary OSWS operation. This screening of site soil conditions was based on the information available from site evaluation information collected by SCDHEC Environmental Health staff in the course of site review for OSWS permitting and available from agency records. These individual site assessments of soils were performed by agency staff, and included evaluation of soil morphological conditions, specifically including soil texture, structure, color, presence of mottling, and determination of any other limiting soil condition. This examination of soil conditions was per SCDHEC staff training and technical guidance, and was ultimately reflected in the OSWS permitting documentation.

SCDHEC technical guidance and regulations stipulate a minimum of six inches of separation between the seasonal high groundwater (SHGW) elevation, based on interpretation of soil morphological and redoximorphic features, to include soil mottling and gleying. The system type prescribed for the site, system depth and configuration, separation distance to seasonal high

groundwater, and hydraulic loading rate are all determined substantially based on the SCDHEC staff evaluation of site and soil conditions.

In addition to soil conditions, the basic criteria for selection of the study sites were as follows:

- Predominantly sandy soil profiles
- Shallow seasonal high groundwater conditions
- OSWS age roughly > 5 years, but < 15 years (to provide for OSWSs that were mature, but reflected current technology, and current regulations)
- System type either conventional, or shallow conventional systems, per SCDHEC local practice
- Year-round single-family residences only, with typical profiles of family occupancy (no commercial establishments, and no vacation-only or rental homes)
- Location in Charleston County, proximal to the coastal area (to provide for minimal variability of SCDHEC Environmental Health procedures and to provide for consistent permitting data)

In addition to these criteria, we attempted to select sites that provided sufficient size, area and absence of obstructions to allow for sampling; sites that did not have a high number of domestic pets or livestock that could potentially affect groundwater quality; sites that allowed for safe and non-destructive access, without extreme constraints by utilities; and sites with cooperative owners willing and interested in the study. Owner approval was documented through a Right of Entry Permit authorizing access to the property.

Key parameters related to system type, system placement, soil conditions, and interpretations of seasonal high groundwater depth for the OSWSs evaluated in this GA are compiled in Table 1. This information was taken from SCDHEC-BEH site evaluation and OSWS permit information, as available. These source documents are provided in the Appendix provided to SCDHEC-BOW as a companion data file to this report. No attempts were made through the present study scope of work to confirm the conditions or observations documented in these permitting documents.

As a result this evaluation emphasized a sampling of typical systems, as permitted through the customary SCDHEC process, in accordance with SCDHEC R.61-56.

2.3 GENERAL SOIL CONDITIONS IN THE STUDY AREA

The majority of the 20 sites sampled in this GA are within a few miles of the coast. It follows that most of the soils in this portion of Charleston County developed on relatively level plains near the coast and inland along the tidal streams and rivers. Development, and the permitting and construction of OSWSs, generally occurs on the higher topographic landscape positions of these plains. Even in these higher topographic positions the soil profiles are still often somewhat to poorly drained and evidence seasonally high groundwater levels.

Based on the screening of candidate OSWSs for this study, via SCDHEC site evaluation and permitting records, the majority of these sites have predominantly sandy soil profiles. In this setting, the predominant soil series are likely to be the Chipley, Seabrook, Scranton series, all of which are somewhat poorly or moderately well drained by USDA-NRCS nomenclature, along with related series which may be better drained, such as the Lakeland and Wando series (SCS-USDA, 1971). Some sites may be more poorly drained, with associated soils such as the Edisto and Sewee series.

Generally, the profiles of most of these series are predominantly sandy throughout. The common morphological indicator that is routinely identified as indicative of limiting conditions in these soils is redoximorphic mottling, indicative of seasonal high water table. Under current SCDHEC BEH guidance, pursuant to R.61-56, such mottling may directly affect the suitability of the site for an OSWS, and the depth, configuration, and type of system that may be permitted.

Based on the screening of the sites studied in this GA, all sites had expressions of these seasonal high water table features. It was not the purpose of this study to validate the accuracy of these soil interpretations, and no site-specific soil assessment was conducted as a part of this study. Rather, the soil interpretations and the resultant OSWS permits and systems were taken at face

value as a reflection of the prevailing OSWS siting and construction process as implemented by SCDHEC over the past 15 years in the study area.

Hence, this study provides an assessment of the SCDHEC approach to interpreting SHGW conditions, and selection of OSWS installation depth, as well as the adequacy of the six-inch separation requirement.

2.4 RELEVANT SYSTEM INSTALLATION SPECIFICATIONS RELATIVE TO SOIL CONDITIONS

Several items of information relating site-specific soil conditions were extracted from the OSWS permit application and construction permit data available through SCDHEC-BEH records. This information is presented in Table 1.

The general sequence of soil textures observed by SCDHEC-BEH staff during the course of OSWS site evaluation are documented for roughly half of the OSWSs studied. Nearly all of the OSWSs for which this data was available indicated loamy sand or sandy soil profiles. Equally important is information with regard to design loading rate or long-term acceptance rate (LTAR). For 18 of 19 systems for which this information was provided, LTARs were 0.8 to 1.0 gpd/ft^2, indicating high permeability soils, interpreted to be likely sandy soil profiles. One additional OSWS had a LTAR of 0.7 gpd/ft^2 indicated.

For nine systems, SCDHEC-BEH records provided some estimation of depth to seasonal high groundwater (SHGW), based on the observation of soil redoximorphic indicators (mottles). Three of these systems indicated depth to SHGW at 12-18 inches below ground surface (bgs), five systems indicated SHGW at 23-29 inches bgs, and one system indicated SHGW at 36 inches bgs. For 19 of 20 OSWSs information was extracted with respect to maximum depth of system installation, which provides a basis for inference of depth to SHGW. Two systems indicated maximum trench installation depth of 6-9 inches bgs, nine OSWSs indicated maximum installation depth

of 24-26 inches bgs. We assumed that a minimum separation distance of 6 inches below OSWS trench bottom was the installation objective for each system. As a result these installation groupings suggest SHGW for these groups of systems on the order of 12-15, 18-24, and 30-32 inches bgs, respectively.

This information generally confirms that nearly all of these systems, were installed in predominantly sandy soil profiles, with shallow seasonal high groundwater conditions.

2.5 GEOLOGIC / HYDROGEOLOGIC SETTING

The geologic medium of interest for this groundwater assessment is the surficial zone. The surficial unit in the Charleston County area, is the terrace deposit called the Ladson Formation, which directly overlies the Cooper Marl (Colquhoun et. al., 1983). The coastal terrace deposits average between 30 and 40 feet in thickness and consist primarily of sand, silt, and clay with commonly occurring seashells that were deposited during a series of marine transgressions and regressions during the Pleistocene and Pliocene Epochs (Aucott et al., 1987). The Ladson Formation is the principal coastal terrace deposit in the vicinity of Charleston County and is the most widespread Pleistocene marine deposit in the Charleston area. The Ladson Formation consists of layered sequences of fine- to coarse-grained sand, silt, and clay that were deposited in a shallow marine environment with a basal phosphatic conglomerate layer (Malde, 1959).

The surficial aquifer occurs within the Ladson Formation, which consists of fine- to coarse-grained interbedded sand, silt and clay. It is an unconfined, laterally extensive aquifer that is about 5 to 40 feet thick in the inland portion of Charleston County, and somewhat thinner nearer the coast. This water table aquifer is recharged by infiltration of precipitation and discharges principally as seepage into surface water bodies. Downward migration into the underlying aquifers is limited by the confining Cooper Marl, which yields very little water and is laterally continuous throughout most of the immediate coastal area of Charleston County.

Depth to groundwater in the surficial aquifer ranges from near surface to approximately 10-15 feet below land surface (bgs). The water table tends to mimic the local topography. In areas proximal to surface waters, the water table is obviously influenced to a variable degree by tidal creeks and drainages. Locally, the water table fluctuates about 1 to 5 feet per year. The predominant groundwater flow direction is south and southeast, towards the major rivers and creeks, although some variations are expressed in these predominant flow paths where creeks incise the landscape on the north side of barrier islands and peninsulas.

2.5 PRECIPITATION

Total annual precipitation in the area varies from approximately 46 to 53 inches per year for the five reporting stations proximal to the study area (http://cirrus.dnr.state.sc.us/cgi-bin/sercc/). These include the McClellanville, Sullivans Island, Charleston City, Charleston Airport, and Edisto Island reporting stations, each of which has a reporting history of nearly 50 years, or substantially longer.

Precipitation at these stations during the 2005 study period ranged slightly above to somewhat below the long term averages, with 105 percent of the annual total precipitation at the City of Charleston station, and 86 to 92 percent of the annual total precipitation at the Charleston Airport and Sullivans Island sites, respectively, for the year. Monthly trends were variable, with three to five months at each of these stations less than 75 percent of the long-term monthly average, and four to five months at each station more than 125 percent of the long-term monthly average. Although the period was slightly below normal precipitation (94 percent of annual average), for these three stations these conditions certainly do not qualify as a drought period, and can be considered within the range of normal.

Summary climatic data relevant to this study is provided in Table 2.

3.0 SCOPE OF INVESTIGATION ACTIVITIES

The approach and procedures employed in the conduct of this Focused Groundwater Investigation (FGI) were presented in a "Field Operations Work Plan (FOWP), SCDHEC – Onsite Wastewater Systems Assessment Program, Lowcountry and Upstate South Carolina" compiled by Pinnacle (North Wind) and GEEL, 28 April 2005, and submitted to SCDHEC's Bureau of Water for review and approval prior to commencement of field operations (Pinnacle and GEEL, 2005a). The procedures proposed under the FOWP were selected to conform to the general requirements and study objectives established in discussions with BOW staff during the formative stages of this project. Also, staff of the SCDHEC Bureau of Environmental Health (BEH), Division of Onsite Wastewater Management (State and Local Trident Area Offices), were involved in developing the strategy and technical approaches incorporated to this study. The assistance of local BEH staff were particularly critical to the records review and the process of selecting candidate sites to be screened for ultimate study sites to be assessed.

Prior to finalization of the FOWP, the general requirements for the project had been identified in the Project Work Breakdown established in the SCDHEC scope of work and contract documents (Pinnacle, 2005). Early in the course of the project it was agreed that we would perform the intended assessment processes and protocols on a trial site. This site is identified in this report as Site D, which is located in the Awendaw community in northern Charleston County. During this trial, conducted on 03 March 2005, oversight was provided by Pinnacle (North Wind), GEEL, and SCDHEC BOW and BEH staff. Through the trial assessment we were able to provide some training for field staff in the identification of key OSWS features, refine field sampling procedures, establish documentation requirements, identify opportunities to modify materials, methods and equipment, and define protocols for implementation of contingencies in the field as may be required on some sites. The results of the lessons learned from the trial run were incorporated into the FOWP.

The field work performed under in this GA was performed in conformance with the protocols established in the FOWP, which specifically incorporated a Field Sampling and Analysis Plan, Quality Assurance Project Plan (QAPP), and Site Safety and Health Plan. In addition to the FOWP, a separate QAPP document was also provided to SCDHEC for review and approval (Pinnacle and GEEL, 2005b).

Field operational procedures and protocols are thoroughly covered in the FOWP. For convenience to the readers of this GAR a brief review of the typical site assessment and sampling process is provided here.

3.1 PRE-SAMPLING SITE ACTIVITIES

In preparation for sampling at each site, utilities were marked by the locally authorized utilities service. Upon arriving at the site the sampling team confirmed the suitability of the site conditions to the study objectives. The OSWS area was identified based on the best available documentation from SCDHEC permit records. Once the OSWS location was established, the locations of all other site constraints, to include utilities, structures, sensitive landscaping, irrigation systems, and other obstructions were confirmed. The septic tank and the infiltration trenches were located by probing with a tile probe; the position of the OSWS trenches was then flagged. The key objective of this activity was to identify the perimeter of the OSWS for subsequent determination of the downgradient reference point on the OSWS, from which all sampling locations would be measured, relative to the groundwater flow gradient.

3.2 DETERMINATION OF GROUNDWATER FLOW GRADIENT

Three temporary piezometers were located around the lot, positioned so as to triangulate the groundwater flow gradient around the OSWS. All temporary piezometers, and all direct push sample wells were installed under SCDHEC Monitoring Well Approval Number 2250, which

authorizes up to 300 piezometers and groundwater samples in conjunction with this study (dated 04 February 2005).

A John Deere 6x4 Gator™-mounted GeoProbe® was used to install the piezometers. Photographs of the drill-rig in operation on representative project sites are provided in Figures 2A-2D. The piezometers were installed as 1-inch, 10-ft long PVC well screens, installed through 2 1/8 inch hollow drill rods. Details of construction of the groundwater devices, as well as the decontamination protocols for all equipment used to access groundwater environments, are provided in the FOWP.

The piezometers were installed so as to reflect local gradient conditions, but sufficiently far from the OSWS to mitigate any influence attributable to groundwater mounding from the OSWS. Piezometers were typically 75 to 150 feet apart, in a roughly equilateral layout, with typically 25-50 feet of separation between the OSWS and the piezometers. Once installed the piezometers were surveyed for horizontal and vertical positioning. Groundwater elevations were determined and flow gradients were calculated.

3.3 GROUNDWATER SAMPLING

Once groundwater flow gradient was established the sampling reference point for each site was selected using the center point of the downgradient edge of the OSWS perimeter. For most sites a total of seven direct push groundwater samples were collected using the John Deere 6x4 Gator™-mounted GeoProbe®.

Under ideal site conditions, and unimpeded by any obstructions, the sampling array was intended to be positioned to intercept a hypothetical longitudinal plume anticipated to emanate from the OSWS. The idealized layout of this sampling array is presented in Figure 3. The Reference point was generally considered to be the center of the OSWS infiltration trench area on the down gradient side of the system. All sampling locations were positioned along a vector projected downgradient from this reference point. Some locations were intentionally offset up to 25 feet from this vector in order

to capture a representative width of any contamination plume that may be associated with the OSWS. Sample DP-1 (direct push sample) was to be located approximately 25 feet downgradient of the center edge of the drainfield, on the assumed center line of the gradient vector. Samples DP-2, DP-3 and DP-4 were all to be located approximately 50 feet downgradient, with DP-3 on the centerline of the gradient, and DP-2 and DP-4 offset 25 feet either side of the primary gradient vector. Samples DP-5 and DP-6 were to be 100 feet downgradient, and offset 25 feet either side of the gradient vector. The seventh sample was intended to be a true background sample. In some cases these samples (identified as BG-1) were additional upgradient or sidegradient DP probes, and in other cases one of the piezometers may have been used to sample background groundwater conditions. Details of the DP sampler device and procedure are presented in the FOWP.

During the course of the study, we elected to install additional DP locations (3 additional per site) for a limited number of sites (5). For these specific sites, three additional samples were identified. Sample DP-7 was to be located only 3 feet downgradient of the edge of the OSWS. Samples DP-8 and DP-9 were to be located approximately 10 feet downgradient of edge of the OSWS, each offset 5 feet either side of the gradient vector. The sampling array had to deviate from this idealized layout on almost every site due to some sort of obstruction. The sampling locations for all 20 sites are combined on Figure 4 illustrate the general array of actual sampling points relative to the idealized sampling objectives. This figure confirms that across the 20 sites we were successful in systematically covering representative areas of the hypothetical plume associated with OSWSs in shallow groundwater systems. The actual sampling arrays for each of the 20 sites are provided as Figures 5A-5T.

Prior to installation of each DP probe the surface soil at the sample point was removed, to minimize potential for translocation of surface contaminants. The groundwater samples were collected using a GeoProbe® DP sampler. The sampler used was 1.0-inch outside diameter of stainless steel construction, inside which a 4-ft long, 3/4 –inch diameter, stainless steel retractable screen was placed. This sampling approach and screen configuration was believed to effectively address the potential for "plunging" of nutrient or pathogen constituents entering the groundwater system from the OSWS. Once the screen was penetrated to the desired depth, the outer housing was retracted, exposing the screen to groundwater. Details of the DP sampler device and procedure are presented

in the FOWP. Once potentiometric levels and groundwater sampling was completed all DP probe cavities were grouted with a bentonite / cement mix to the ground surface.

3.4 FIELD SAMPLE ANALYSIS

Details regarding the collection of the groundwater samples are documented in the FOWP. The field parameters, pH, temperature, specific conductivity, and chloride (specific ion probe) were measured in the field using field instruments. These parameters were used to 1) confirm stable groundwater samples were attained, and 2) to preliminarily assess the location of each sample relative to the anticipated OSWS plume. Details of the field analysis as well as sample handling protocols are provided in the Quality Assurance Project Plan (QAPP) for the project (Pinnacle & GEEL, 2005a).

3.5 LABORATORY ANALYSIS

Each groundwater sample from each site was analyzed for the following parameters:

- Nitrate-Nitrite Nitrogen
- Total Kjeldahl Nitrogen
- Total Phosphorus
- Fecal Coliform

The chemical analyses were processed through the laboratories of GEEL per the FOWP and the QAPP. The bacteriological analyses were conducted at Trident Laboratories.

Supplemental samples collected from the three additional samples at five of the 20 sites were analyzed per the above specifications. For each of these supplemental samples, an additional sample was collected for bacteriological analysis through SCDHEC's laboratory.

Details regarding the analytical procedures and protocols employed in this study are provided in the QAPP document (Pinnacle and GEEL, 2005a).

3.6 DATA ANALYSIS AND STATISTICAL TRENDS REVIEW

Based on character, quality, and technical utility of various information sources, records were screened to confirm that they met data quality objectives, then imported into the JMP™ (SAS Institute Inc., Cary, NC, SAS, 2002) statistical analysis package. Data were analyzed using established statistical methodology for temporal, spatial, and parametric trends.

With respect to the objectives of this study of OSWS effects on groundwater resources, statistical analysis was conducted to address these simple questions:

- Do differences in parameter concentrations exist among the various 20 OSWS sites?
- Do differences in parameter concentrations exist across sampling zones, i.e. as a function of distance from the OSWS?
- Do differences in concentrations exist as a function of depth to groundwater?
- Do differences in concentrations exist as a function of separation distance between OSWS trench bottom and observed groundwater level?
- Do differences in concentrations exist as a function of season?

In JMP™, the "Fit Y by X" platform was used for statistical analysis. A one-way analysis of variance (ANOVA) table was used to determine if at least one sample mean was statistically significant from the others. Pairs of means were compared for pairwise significant differences using the Student's t-test, and graphically illustrated with comparison circles. A 5% level of significance (α=0.05) was used throughout.

The reader is directed to the Appendix for an interpretative guide to understanding graphical presentation of the statistical analyses.

4.0 ASSESSMENT RESULTS

The objective of this Groundwater Assessment was to address the effects of typical OSWSs upon shallow groundwater resources. This study focused on a technical survey of the impacts of, and performance of, typical OSWSs, installed in conformance with SCDHEC's onsite wastewater management program over the past roughly 15 years. The OSWSs assessed in this process are considered to be a representative population of such systems within the study criteria. The particular focus of this study was OSWSs installed in vulnerable groundwater environments, that is, sandy soil profiles with shall depths to seasonally high groundwater.

4.1 GENERAL OBSERVATIONS

All OSWSs were observed to be in good apparent operating condition at the time of sampling. None of the 20 system owners complained of any malfunctions, and no symptoms of OSWS surfacing or hydraulic failure were observed in the field. No attempts were made to make any assessment of the condition of the septic tank or the infiltration trenches. Wastewater flows and wastewater quality were not measured in this study and were assumed to be within the normal range of characteristics for OSWSs serving single family residences locally.

All field methods employed were executed without significant problems. The John Deere 6x4 Gator™-mounted GeoProbe® provided an expedient and non-destructive means for obtaining shallow groundwater samples on all sites. This approach to collecting one-day "snapshot" assessments of groundwater conditions proved efficient, timely, and mitigated any significant or objectionable impacts to the homeowners' property and landscaping. The process was nonetheless relatively time consuming, typically requiring a full day of field operations for a three-person crew, in order to effect all of the required tasks, to include OSWS location, determination of groundwater flow, required locational surveys, sampling, sample handling, equipment decontamination, abandonment of the temporary wells and DP holes, and site cleanup. All factors considered, the

methods employed were considered highly effective for the soil, groundwater, and environmental conditions present in this study, and to meet all technical requirements and objectives of this study.

4.2 WATER QUALITY – FIELD AND ANALYTICAL RESULTS

All water quality field and analytical results are summarized in Table 3 for all 20 sites, all samples, and all parameters. Water quality parameters measured in the field included pH, temperature, specific conductivity, and chloride (by specific ion detector). Analytical parameters determined in the laboratory included Nitrate-Nitrite Nitrogen (NO_3-NO_2), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), and Fecal Coliforms. NO_3-NO_2, TKN, and TP were analyzed in GEEL facilities, and Fecal Coliforms were determined through Trident Laboratories. A limited number of supplemental samples were analyzed for Fecal Coliforms through SCDHEC's Region Laboratory (see subsequent discussion). Total Nitrogen (TN) was determined as the sum of NO_3-NO_2 plus TKN (sum of oxidized and reduced N-forms). All laboratory analytical reports, QA/QC summaries, and chain of custody reports are provided in the supplementary appendix files for each site.

4.2.1 Nitrogen Trends

Background groundwater samples (BG series samples) at most sites are dominated by reduced forms of nitrogen, with an average of approximately 80 percent of the nitrogen being manifested as TKN. However, oxidized forms of nitrogen (NO_3-NO_2) appear to dominate (89 percent) nitrogen species in most samples collected downgradient of the OSWSs. It is assumed that the majority of the TKN is likely ammonia (NH3) as opposed to organic forms of nitrogen.

The spatial concentrations of N-species indicate significant loading of nitrogen proximal to the OSWSs, with the highest TN in the groundwater samples collected in the zone closest to the systems (3-5 ft zone) at 10.2 mg/l, of which 81 percent was NO_3-NO_2. Concentrations of TN generally decreased with increasing distance from the OSWSs. However, somewhat higher proportions of NO_3-NO_2 were observed within approximately 50 ft of the OSWSs. The

proportion of the NO_3-NO_2 component of TN increased with distance from the systems peaking in the samples in the zone 45-76 ft from the OSWSs with oxidized N-forms accounting for 93 percent of a TN concentration of 6.0 mg/l. For the samples from the zone located 100-135 ft downgradient of the systems this nitrified component of the TN decreased to 71 percent of a TN concentration of 1.4 mg/l. Across all 20 systems, TN concentrations dissipated by an average 86 percent from the near system locations to those roughly 100 ft downgradient from the OSWSs.

These trends in nitrogen concentrations suggest a classic nitrification effect associated with OSWSs. In soil and groundwater settings such as represented in this population of systems, an increase in TN, dominated by reduced N-forms close to the system would be expected, with increased nitrification of the reduced fractions with some distance from the systems. Dilution with increasing distance would likewise be expected.

Nitrate is the only chemical constituent monitored in this groundwater assessment for which there is an established MCL, 10 mg/l (USEPA, 2002). Of the 154 samples analyzed in this study 24 (15.6 percent) had NO_3-NO_2 concentrations exceeding the MCL. All 24 samples exceeding the NO_3 MCL were within 65 feet of the OSWS, with 16 of these within 45 ft of the systems.

4.2.2 Phosphorus Trends

Concentrations of total phosphorus in groundwater do not do not reflect discernable trends downgradient of the OSWSs. Interestingly the background groundwater samples have among the highest TP concentrations, averaging 2.1 mg/l. Concentrations of TP in samples closest to the systems were the lowest of all sample groups, 0.77 mg/l. Concentrations of TP in samples in the most distant sampling zone, roughly 100 ft downgradient, averaged 1.17 mg/l.

Phosphorus is strongly bound to soil particles, especially clays and organic matter. Soils with higher concentrations of iron and aluminum, and associated mineralogies, have even higher capacities to adsorb phosphorus. Hence, although phosphorus is a significant constituent of septic tank effluent, TP is not generally highly mobile in soil environments, even in sandy soils (USEPA, 1981).

4.2.3 Fecal Coliform Trends

Fecal coliform bacteria are a group of organisms present in large numbers in the digestive tracts of humans and other warm blooded animals. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. Fecal organisms are not particularly harmful in their own right, but the presence of fecal contamination is an indicator of the potential presence of other more harmful organisms and pathogens. So, the presence of FC indicates that a potential health risk exists for individuals exposed to water with elevated bacterial counts. The SC surface water quality standards establish a surface water standard for fecal coliform of 200 colonies/100 ml (SCDHEC, 2001). Although there is no formally adopted Federal MCL for fecal coliforms the recommended level for drinking water is zero colonies/100 ml (USEPA, 2002).

Fecal coliform bacteria are found at high concentrations in septic tank effluent, and hence, their occurrence in groundwater adjacent to OSWSs is indicative of untreated or incompletely treated sewage. Numerous other bacterial organisms are often used for assessing contamination of water resources by bacteria, but FC is the only organism for which a regulatory water quality standard exists in SC. Because FC is generally regarded as a conservative indicator of bacterial contamination, and because it is the only bacterial component for which there are surface water standards, this was the only bacterial indicator evaluated in the course of this study.

The results of the analysis of groundwater samples from this study found almost no detectable levels of FC bacteria. Of 166 samples collected and analyzed only four samples were found to have enumerable counts of bacteria above detection limits. Three of these detections were found by the project commercial lab (Trident) and were associated with Site O. Two of these samples (Samples DP-5 and DP-6) were collected 100 feet from the OSWS, and produced counts of 50 and 13 c/100ml. The other Site O sample (Sample DP-8) was located 10 feet from the system and produced a count of >1600 c/100 ml. This was the only sample collected in the study with an exceedance of the water quality standard. The other detection for FC was found by the

SCDHEC laboratory, for a sample from Site R sample (Sample DP-7). This sample was taken 3 feet from the system and produced a count of 8 c/100 ml.

After sampling the first several sites, in Spring 2005, we observed that the results of the bacteria screening results were remarkably free of detectable bacteria. Based on these results SCDHEC and its consultants agreed to modify the project scope to include supplemental groundwater samples. These samples were intentionally positioned much closer to the OSWSs. Duplicate samples were collected and bacterial analysis was performed by both the Trident Lab (per the FOWP and QAPP) but also the SCDHEC District laboratory, providing an additional measure of quality assurance with regard to FC analysis. These samples were collected at Sites L, M, O, S and R. These samples were collected very close to the OSWSs, with one sample at 3 feet from the downgradient edge of the perimeter trench, and the other two at 10 feet from the system edge. The results of these samples are provided in Table 3. Note that for the supplemental samples collected from Site O, no data report was received for the samples analyzed by the SCDHEC laboratory; hence, those samples are footnoted in Table 3 as "not reported".

The results of these "supplemental" bacteria samples were consistent from the two laboratories. Only the one supplemental sample, from Site R, (Sample DP-7) taken 3 feet from the OSWS, had a detectable concentration of FC, with a count of 8 c/100 ml.

These summary observations with regard to indicator organisms suggest that the OSWSs and their associated natural soil systems are very effective in removing FC within a few feet of the system edge. Four of 166 samples (2.4 percent) were found to have detectable levels of fecal organisms. Only one of these samples (0.6 percent) had FC values exceeding the surface water standard. These findings, to include duplicate analysis on 12 samples, confirm the effectiveness of these OSWSs in removing fecal bacteria. These observations are quite significant, especially considering the rapid permeability of the site soils, and the prevailing shallow groundwater conditions.

4.2.4 Other Indicators

The water quality indicator parameters were used primarily to assess sample location relative to the expected plume position. These parameters were also useful in showing the effects of the OSWS on groundwater. Temperature showed an average increase of 1 °C in those samples in close proximity to the OSWS, relative to all positions further from the systems. Likewise, specific conductivity was significantly higher in those samples closest to the system, indicating the contaminant loading effects of the systems. The indicator parameter pH did not vary appreciably by distance from the system. Chloride was substantially elevated close to the systems.

4.3 WATER QUALITY – ANALYSIS OF VARIANCE

As described in Section 3.6, statistical analysis tools were utilized to assess water quality trends among various groups of samples. The results of these ANOVAs are presented in the Figures, and discussed below.

4.3.1 Comparison of Individual Sites

The twenty sites were compared using ANOVA techniques. The results of this ANOVA evaluation are presented in Figures 6A-6H. This analysis indicates significant differences among sites. The OSWSs evaluated through this GA are all similar in type, configuration, service age, and soils and groundwater setting. Available information does not provide any readily apparent explanation for the differences. However, a variety of contributing factors may include site background, historical site use (e.g. fertilization and livestock use), wastewater strength, wastewater production, vegetation effects, and variations in soils and groundwater factors. The

variability observed between OSWSs here is interpreted to be representative of the natural range of conditions and performance of systems locally.

Groundwater samples from the downgradient OSWS "plume area" assessed in this GA produced results generally within the range of conditions anticipated from such systems. These results are interpreted as representative of a variety of sites and a natural range of conditions in the local soils and hydrogeologic setting, as desired. This approach to sampling and review of OSWS performance is believed to be far more meaningful than intensive continuing sampling from a single site.

4.3.2 Comparison With Respect to Distance from the OSWS

The samples were categorized into proximity groups to assess statistical significance of any apparent differences relative to OSWS position, and relative to background samples. These sample groupings are A (3-5 ft from OSWS edge), B (10-15 ft), C (18-40 ft), D (45-76 ft), E (100-135 ft), and F (background or REF (reference) samples). Results of this ANOVA are presented in Figures 7A-7H.

For NO_3-NO_2 results, sample Groups A, B, C, and D were statistically similar, but significantly different (α=0.05) from Group E and the Group REF (background) samples. This simply confirms the loading effect of the OSWSs relative to background, and the apparent dilution of the loading effect with distance from the system as manifested in NO_3-NO_2 concentrations.

For TKN, Group A was significantly higher in concentration than all other groups. Groups A and C were also significantly different from Groups D and E. Only Group A was different from Group REF (background). This suggests significant ammonia loading to the groundwater system proximal to the OSWSs, as expected.

For TN, Groups A, B and C were again significantly higher in concentration than Groups E and REF. Some distinctions were also present within near and far sample groups.

For TP, patterns of difference were more obscure, and less readily explainable. Groups C and REF were significantly higher in concentration than Groups D and E. Some distinctions were also present within near and far sample groups.

Some field indicator parameters proved more distinctive among Sample Groups than others. The parameters pH, temperature, and Chloride reflected no significant differences among the groups. Specific conductivity was significantly higher in Groups A and C than Groups D, E and REF.

4.3.3 Comparison With Respect to Depth Variables and Time of Year

The results of each field indicator parameter and each laboratory chemical parameter were evaluated to determine if there were discernable trends and differences with respect to site groundwater conditions and time of year. With respect to observed depth to groundwater (bgs), and separation between OSWS trenches and observed groundwater depth, analysis of site means showed no substantive or statistically significant trends for any major parameter for either of these depth variables. Likewise, with respect to time of year, a comparison of site means demonstrated that no substantive or statistically significant trends for any major parameter. These results did not warrant graphical or tabular presentation in this report.

5.0 SUMMARY AND CONCLUSIONS

A targeted Groundwater Assessment of limited scope was conducted to evaluate groundwater quality in the surficial groundwater zone surrounding typical OSWSs. The specific objective of this GA was to examine the performance of representative OSWSs installed in sandy soils and shallow groundwater environments, and to assess the impacts of these systems on the shallow groundwater resources. This soil / groundwater scenario was believed to represent one of the most vulnerable environments for potential transport of OSWS contaminants to groundwater and surface water resources.

Twenty typical OSWSs serving typical single-family residential dwellings were selected for groundwater sampling. Selected systems were between roughly five and fifteen years in service, and were sited, permitted and installed in accordance with SCDHEC R.61-56 requirements. All sites were located in Charleston County and all were installed in sandy soil profiles with shallow groundwater conditions. The specifications and construction of each system were confirmed to be suitable for study objectives prior to sampling.

A sampling and analysis program was developed to enable expedited sampling with minimal site disturbance in residential property settings. At each site groundwater flow gradients were determined using temporary piezometers. Groundwater samples were then collected from temporary wells, to include one background sample and six to nine samples downgradient of the OSWS. Indicator parameters were measured in the field on each sample. Laboratory analyses were conducted on each sample to determine nutrient concentrations and to assess the presence of indicator bacteria. All sampling and analytical activities were performed in strict accordance with SCDHEC-approved FOWP and QAPP protocols. All of these assessment and sampling activities were conducted in the course of one day on each site. All sampling activities were performed between March 2005 and January 2006, covering a range of representative climatic conditions over a one-year period, during which precipitation was confirmed to be normal.

Key observations from this OSWS / groundwater assessment study included the following:

- With respect to OSWS conditions, at the time of sampling all OSWSs were confirmed to be in good and compliant operating condition. In 19 of 20 systems, the minimum six-inch separation between the OSWS trenches and seasonal high ground water conditions, as specified in R.61-56, appeared to be satisfied, based on actual groundwater observations. As observed from field-measured groundwater levels, the average separation was actually over 40 inches, and ranged from -5 inches (apparent trench inundation at one site) to 93 inches. Even considering that several of the systems were not functioning at seasonal high groundwater levels on the dates sampled, this difference suggests that SCDHEC soil interpretations were generally quite conservative.

- A total of 166 samples were analyzed for the presence of the indicator organism fecal coliform. Of these, 97.6 percent of the samples indicated no detections of fecal organisms. Only one sample was found to have detectable concentrations of fecal organisms above regulatory standards for surface waters. Duplicate samples analyzed by two independent laboratories on samples collected in close proximity to the OSWSs from five sites. These duplicate analyses confirmed the general absence of detectable levels of indicator bacteria in groundwater samples.

- Elevated concentrations of nutrients derived from the OSWSs were found in groundwater immediately adjacent to the systems. Reduced forms of nitrogen were elevated, as expected, adjacent to the OSWSs but appeared to be transformed readily to oxidized forms (NO_3-NO_2) within a distance of tens of feet from the systems. At background locations, groundwater samples indicated 26 percent of the nitrogen was in the NO_3-NO_2 form, compared to 64 percent of locations downgradient of the OSWSs. Compared to the federal MCL of 10 mg/l for NO_3, no background groundwater samples, and 18 percent of groundwater samples from locations downgradient of the OSWSs, exceeded the standard. However, no exceedances of the 10 mg/l standard were observed beyond 65 feet from any OSWS.

- Even in sandy soils phosphorus from OSWS sources is typically not expected to be highly mobile. This study confirmed no significant trends with respect to total phosphorus in groundwater samples.

- No apparent trends were observed for any measured parameter with respect to depth to groundwater or separation distance between OSWS trenches and groundwater.

- No apparent trends were observed for any measured parameter with respect to time of year.

In summary, the following conclusions are offered with respect to the OSWSs sampled through this study, and their effects on the associated downgradient groundwater resources:

1) The soils surrounding the OSWSs very effectively removed and attenuated bacteria and nutrients derived from OSWS septic tank effluent.

2) Groundwater samples indicated that nitrification of nitrogen constituents from OSWSs occurs near the system, at least in these sandy soils, followed by dilution in the near downgradient zone. No exceedances of the federal MCL for nitrate were observed more than 65 feet from any OSWS.

3) Effects of OSWSs on groundwater in the systems evaluated were very localized and did not result in extensive or extreme degradation of water quality of shallow surficial aquifers. It follows that it is not likely that these systems will have appreciable effects on deeper potable water supply aquifers, or on surface waters more than 50 feet from OSWS components.

4) Based on observations of these 20 typical residential OSWS installations, site and soil interpretations based on the R.61-56 requirement of a minimum of six-inches separation between OSWS components and groundwater appear to generally be very conservative.

5) Based on results of groundwater sampling from these 20 representative OSWSs, the siting, system specification, and construction of OSWSs, according to R.61-56, as implemented locally in Charleston County, appears to be reasonably protective of groundwater resources.

6.0 REFERENCES

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Table 1. Summary of Relevant Onsite Wastewater System Site, Soils, and Design Information [1]
10 Mar 2005 – 18 Jan 2006
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites – Charleston County
SCDHEC Project J04-N058-MJ

Site	Data Derived from SCDHEC Permit Information					Data Determined From Groundwater Investigation		
	Predominant Soil Profile Texture (USDA)	Inferred Seasonal High Groundwater Depth (inches bgs) [2]	Design Long-Term Acceptance Rate (gpd/ft^2)	Design Flow (gpd)	Maximum OSWS Trench Installation Depth (inches bgs)	Date of Initiation of Groundwater Investigation Activities (yrmoda)	Measured Groundwater Depth (Mean) – Day of Investigation (inches bgs) [3]	Vertical Separation: Trench-Bottom to Groundwater on Investigation Date (inches) [4]
A	loamy sand	29	0.9	360	26	051004	67	41
B	NA [5]	NA	NA	NA	24 [6]	050614	81	57 [6]
C	NA	NA	0.9	480	24	050516	49	25
D	loamy sand	24	0.9	360	18	050303	67	49
E	loamy sand	23	0.9	360	18	050602	44	26
F	NA	NA	0.9	360	18	050518	35	17
G	NA	NA	0.7	480	18	050510	55	37
H	sand	36	0.9	360	26	060118	62	36
I	NA	NA	0.9	360	24	050509	55	31
J	NA	NA	0.8	360	12	050310	54	42
K	NA	NA	0.9	360	24	050523	69	45
L	loamy sand	18	0.9	360	9	051025	42	33
M	loamy sand (sl-ls)	12	0.9	360	14	051027	35	21
N	loamy sand (sl-ls)	28	0.9	720	24	050524	63	39
O	NA	NA	0.8	480	15	050921	58	43
P	NA	NA	1.0	360	24	050503	74	50
Q	NA	NA	1.0	360	24	050609	81	57
R	loamy sand	26	0.9	360	18	050510	97	79
S	loamy sand (sl-scl)	16	0.8	240	6	051006	99	93
T	NA	NA	0.8	360	18	051122	13	-5

[1] From SCDHEC-BEH OSWS Permit Application, and OSWS Construction Permit files.
[2] Inferred Depth to Seasonal High Groundwater (SHGW) based on data provided on SCDHEC site evaluation forms.
[3] Groundwater depth as determined via piezometers installed on date of investigation.
[4] Vertical separation = difference in observed groundwater depth (bgs) and maximum OSWS trench installation depth (bgs).
[5] NA – Information Not Available from file documents.
[6] Value for OSWS "B" is assumed to be 24" as typical conventional placement. No SCDHEC permit forms indicating depth of trench placement were available.

Table 2. Summary of Relevant Precipitation Data
01 Jan 2005 – 31 Dec 2005
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites – Charleston County
SCDHEC Project J04-N058-MJ

Station	Historical Annual Mean Precipitation	Total Precipitation for CY 2005	2005 Annual Precipitation as Percent of Historic Mean	2005 Months < 75 % of Historic Monthly Mean	2005 Months > 125 % of Historic Monthly Mean
McClellanville (385628)	**53.24**	**Not Available**	**Not Available**	**Not Available**	**Not Available**
Sullivans Island (388405)	**47.45**	**43.46**	**91.6**	**5**	**4**
City of Charleston (381549)	**46.06**	**48.33**	**104.9**	**3**	**5**
Charleston WSO Airport (381544)	**50.16**	**42.91**	**85.6**	**5**	**4**
Edisto Island (382730)	**47.89**	**Not Available**	**Not Available**	**Not Available**	**Not Available**
Mean	***48.96***	***44.90***	***94.0***	***4.3***	***4.3***

From:

Southeast Regional Climate Center Website, sercc@dnr.state.sc.us , http://cirrus.dnr.state.sc.us/cgi-bin/sercc/
National Weather Service Forecast Office, Charleston, South Carolina (http://www.erh.noaa.gov/er/chs/)

Table 3. Summary of Field and Analytical Water Quality Results
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

Site	Date Sampled	Sample ID	Sampling Zone *	Distance from System Edge along Center Line (ft)	Distance Offset from Center Line (ft)	Direction of Offset from Center Line	Ground-water Depth (ft below TOC)	NO_3/NO_2 (mg/L) **	TKN (mg/L) **	TN (mg/L)	TP (mg/L) **	Fecal Coliforms (c/100ml) ***		pH	Temp (°C)	Specific Conductivity	Chloride
												Lab1	Lab2				
A	4-Oct-05	BG-1	F	6	68	L	5.48	***0.00850***	0.0980	0.098	0.111	< 2	NA	5.2	22.8	86.3	10.3
A	4-Oct-05	DP-1	C	25	0	C	5.48	0.27400	1.3000	1.574	1.220	< 2	NA	6.4	23.5	88.1	6.1
A	4-Oct-05	DP-2	D	50	25	R	5.48	0.02710	2.0200	2.047	0.155	< 2	NA	6.2	24.5	93.4	4.0
A	4-Oct-05	DP-3	D	50	0	C	5.48	0.02670	0.1520	0.179	0.074	< 2	NA	6.3	24.2	89.7	5.9
A	4-Oct-05	DP-4	D	50	25	L	5.48	0.02600	0.1020	0.128	0.388	< 2	NA	6.3	24.0	90.5	5.5
A	4-Oct-05	DP-5	E	100	25	R	5.48	0.73300	0.1320	0.865	0.309	< 2	NA	6.0	24.3	127.3	6.4
A	4-Oct-05	DP-6	E	100	25	L	5.48	0.75100	0.1360	0.887	0.247	< 2	NA	5.9	24.5	108.4	9.2
B	14-Jun-05	BG-1	F	30	200	L	7.15	0.00972	***0.0050***	0.010	0.292	< 2	NA	6.4	21.3	196.3	47.1
B	14-Jun-05	DP-1	C	25	0	C	7.15	1.98000	0.4640	2.444	0.084	< 2	NA	7.0	21.7	716.0	109.7
B	14-Jun-05	DP-2	D	50	0	C	7.15	2.83000	0.2510	3.081	0.039	< 2	NA	7.0	21.0	529.0	75.0
B	14-Jun-05	DP-3	D	50	25	R	7.15	6.15000	0.4270	6.577	0.042	< 2	NA	6.9	20.0	627.0	78.4
B	14-Jun-05	DP-4	D	50	25	L	7.15	0.00645	***0.0050***	0.006	0.037	< 2	NA	6.4	22.3	212.0	52.1
B	14-Jun-05	DP-5	E	100	25	R	7.15	3.76000	0.2260	3.986	0.075	< 2	NA	6.5	22.0	360.0	100.3
B	14-Jun-05	DP-6	E	100	25	L	7.15	0.01960	0.0800	0.100	0.435	< 2	NA	6.9	24.8	277.0	40.2
C	16-May-05	BG-1	F	83	78	R	4.40	0.00900	0.2690	0.278	0.256	< 2	NA	6.2	19.2	116.7	20.3
C	16-May-05	DP-1	C	25	0	C	4.40	7.78000	0.6280	8.408	0.249	< 2	NA	6.3	20.7	465.0	117.2
C	16-May-05	DP-2	D	50	0	C	4.40	0.01600	0.0250	0.041	0.084	< 2	NA	5.9	19.0	96.0	27.8
C	16-May-05	DP-3	D	50	25	L	4.40	14.40000	1.6300	16.030	2.060	< 2	NA	6.5	19.3	506.0	143.8
C	16-May-05	DP-4	C	25	25	L	4.40	8.33000	0.9020	9.232	0.229	< 2	NA	6.6	19.4	1049.0	339.0
C	16-May-05	DP-5	C	25	50	L	4.40	30.30000	0.8660	31.166	0.300	< 2	NA	6.7	19.2	962.0	319.0
C	16-May-05	DP-6	D	50	50	L	4.40	10.10000	0.8320	10.932	0.628	< 2	NA	7.0	18.7	730.0	256.0
D	3-Mar-05	BG-1	F	-45	115	R	5.58	0.00932	0.1420	0.151	0.017	< 2	NA	5.7	15.2	107.0	NA
D	3-Mar-05	DP-1	C	25	25	L	5.58	34.20000	0.7500	34.950	***0.006***	< 2	NA	6.6	15.1	728.0	NA
D	3-Mar-05	DP-2	D	50	25	L	5.58	13.30000	0.1180	13.418	0.020	< 2	NA	5.4	15.5	255.0	NA
D	3-Mar-05	DP-3	E	120	15	L	5.58	0.00673	0.2280	0.235	0.043	< 2	NA	5.4	16.5	83.0	NA
D	3-Mar-05	DP-4	D	50	0	C	5.58	0.53800	0.1380	0.676	0.018	< 2	NA	6.2	15.8	155.0	NA
D	3-Mar-05	DP-5	E	100	10	R	5.58	0.00893	0.0650	0.074	0.018	< 2	NA	5.7	16.0	119.0	NA
D	3-Mar-05	DP-6	E	135	20	L	5.58	0.01940	0.0860	0.105	0.014	< 2	NA	5.7	16.5	126.0	NA

* Zone A=3-5 ft from OSWS, B=10-15, C=18-40, D=45-76, E=100-135, F=bckgrnd.
** Italicized bold = half detection limits for "ND" or non-detects.
*** Labs 1=Trident, 2=SCDHEC. NA=Not Analyzed. NR=Not Reported.

Table 3. Summary of Field and Analytical Water Quality Results
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

Site	Date Sampled	Sample ID	Sampling Zone *	Distance from System Edge along Center Line (ft)	Distance Offset from Center Line (ft)	Direction of Offset from Center Line	Ground-water Depth (ft below TOC)	NO_3/NO_2 (mg/L) **	TKN (mg/L) **	TN (mg/L)	TP (mg/L) **	Fecal Coliforms (c/100ml) ***		pH	Temp (°C)	Specific Conductivity	Chloride
												Lab1	Lab2				
E	2-Jun-05	BG-1	F	-170	25	L	3.97	0.00639	5.1800	5.186	1.030	< 2	NA	5.6	23.0	432.0	63.1
E	2-Jun-05	DP-1	A	5	0	C	3.97	4.70000	0.1800	4.880	***0.005***	< 2	NA	5.4	22.5	155.8	8.5
E	2-Jun-05	DP-2	B	10	0	C	3.97	5.17000	0.1670	5.337	0.028	< 2	NA	5.6	22.3	151.4	9.3
E	2-Jun-05	DP-3	B	15	0	C	3.97	15.60000	1.2800	16.880	1.160	< 2	NA	6.1	21.5	592.0	84.4
E	2-Jun-05	DP-4	D	45	0	C	3.97	34.80000	1.1000	35.900	0.799	< 2	NA	6.4	21.9	968.0	193.5
E	2-Jun-05	DP-5	C	30	15	L	3.97	16.20000	0.6170	16.817	***0.005***	< 2	NA	6.3	20.1	846.0	201.0
E	2-Jun-05	DP-6	E	100	0	C	3.97	0.00468	0.3410	0.346	0.103	< 2	NA	5.8	21.5	416.0	119.9
F	18-May-05	BG-1	F	NA	NA	NA	2.48	0.52300	0.5190	1.042	0.453	< 2	NA	6.4	22.9	1195.0	1857.0
F	18-May-05	DP-1	C	25	0	C	2.48	1.67000	0.2910	1.961	0.377	< 2	NA	6.4	19.5	462.0	1137.0
F	18-May-05	DP-2	D	50	0	C	2.48	0.02000	0.2570	0.277	0.709	< 2	NA	6.6	19.0	334.0	947.0
F	18-May-05	DP-3	D	50	25	R	2.48	0.88000	0.8230	1.703	1.580	< 2	NA	6.4	20.6	622.0	1370.0
F	18-May-05	DP-4	D	50	25	L	2.48	0.02000	0.8390	0.859	1.300	< 2	NA	6.4	18.7	3130.0	> 1999.9
F	18-May-05	DP-5	E	100	25	R	2.48	0.02000	1.6300	1.650	3.540	< 2	NA	6.4	21.4	952.0	1813.0
F	18-May-05	DP-6	E	100	25	L	2.48	0.02000	1.7900	1.810	1.770	< 2	NA	6.3	19.2	2260.0	> 1999.9
G	10-May-05	BG-1	F	80	99	R	4.77	0.02000	0.1000	0.120	2.840	< 2	NA	5.9	20.2	53.6	21.8
G	10-May-05	DP-1	C	25	0	C	4.77	32.50000	0.1200	32.620	0.444	< 2	NA	6.0	20.6	524.0	73.2
G	10-May-05	DP-2	D	50	0	C	4.77	1.24000	0.1850	1.425	0.922	< 2	NA	5.7	20.1	53.6	21.8
G	10-May-05	DP-3	D	50	25	L	4.77	5.10000	0.1070	5.207	0.569	< 2	NA	5.7	19.8	189.3	21.9
G	10-May-05	DP-4	D	75	0	C	4.77	1.00000	0.1000	1.100	2.170	< 2	NA	5.8	19.1	80.1	20.5
G	10-May-05	DP-5	E	100	25	R	4.77	2.13000	0.1480	2.278	10.000	< 2	NA	5.8	19.3	102.9	23.6
G	10-May-05	DP-6	E	100	25	L	4.77	0.02000	0.3590	0.379	0.320	< 2	NA	5.7	20.7	759.0	97.3
H	18-Jan-06	BG-1	F	-58	25	L	5.15	5.40000	0.2800	5.680	1.120	< 2	NA	7.7	17.4	173.4	4.8
H	18-Jan-06	DP-1	B	10	0	C	5.15	4.46000	0.2290	4.689	3.240	< 2	NA	6.5	18.3	87.8	1.4
H	18-Jan-06	DP-2	C	25	0	C	5.15	2.89000	0.2460	3.136	3.850	< 2	NA	7.4	19.0	62.6	0.8
H	18-Jan-06	DP-3	B	10	10	R	5.15	1.41000	0.2180	1.628	7.690	< 2	NA	6.3	17.9	52.9	0.4
H	18-Jan-06	DP-4	B	10	10	L	5.15	33.10000	0.5700	33.670	2.150	< 2	NA	5.4	18.3	610.0	61.3
H	18-Jan-06	DP-5	C	25	15	R	5.15	4.45000	0.1680	4.618	2.610	< 2	NA	5.9	18.0	71.7	0.7
H	18-Jan-06	DP-6	C	25	15	L	5.15	3.74000	1.4200	5.160	2.470	< 2	NA	5.8	18.8	121.2	0.8

* Zone A=3-5 ft from OSWS, B=10-15, C=18-40, D=45-76, E=100-135, F=bckgrnd.
** Italicized bold = half detection limits for "ND" or non-detects.
*** Labs 1=Trident, 2=SCDHEC. NA=Not Analyzed. NR=Not Reported.

Table 3. Summary of Field and Analytical Water Quality Results
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

Site	Date Sampled	Sample ID	Sampling Zone *	Distance from System Edge along Center Line (ft)	Distance Offset from Center Line (ft)	Direction of Offset from Center Line	Ground-water Depth (ft below TOC)	NO_3/NO_2 (mg/L) **	TKN (mg/L) **	TN (mg/L)	TP (mg/L) **	Fecal Coliforms (c/100ml) ***		pH	Temp (°C)	Specific Conductivity	Chloride
												Lab1	Lab2				
I	12-May-05	BG-1	F	-58	39	R	4.90	0.02000	0.2280	0.248	0.999	< 2	NA	6.5	18.5	215.0	53.9
I	12-May-05	DP-1	B	15	0	C	4.90	4.48000	0.4630	4.943	0.196	< 2	NA	5.8	21.3	320.0	34.3
I	12-May-05	DP-2	C	20	5	L	4.90	8.87000	0.5290	9.399	2.780	< 2	NA	5.9	19.7	376.0	42.4
I	12-May-05	DP-3	B	10	0	C	4.90	7.17000	0.4330	7.603	0.500	< 2	NA	6.0	20.1	311.0	27.5
I	12-May-05	DP-4	C	30	0	C	4.90	14.70000	0.3730	15.073	0.641	< 2	NA	6.0	20.3	514.0	58.2
I	12-May-05	DP-5	C	22	9	R	4.90	4.38000	0.5800	4.960	0.440	< 2	NA	6.2	20.2	302.0	33.0
I	12-May-05	DP-6	C	40	0	C	4.90	14.60000	0.8250	15.425	1.570	< 2	NA	6.0	20.6	497.0	58.9
J	3-Oct-05	BG-1	F	NA	NA	NA	4.88	***0.00850***	0.1560	0.156	2.800	< 2	NA	6.7	24.4	163.0	166.0
J	3-Oct-05	DP-1	C	25	0	C	4.88	0.19200	4.0200	4.212	6.260	< 2	NA	7.9	24.8	703.0	294.0
J	3-Oct-05	DP-2	C	38	0	C	4.88	0.47700	NA	NA	0.507	< 2	NA	6.6	24.4	171.0	174.0
J	3-Oct-05	DP-3	D	50	0	C	4.88	1.33000	0.4100	1.740	17.700	< 2	NA	6.7	24.2	272.0	148.0
J	3-Oct-05	DP-4	D	50	25	L	4.88	5.90000	0.1180	6.018	6.090	< 2	NA	7.4	25.1	332.0	320.0
J	3-Oct-05	DP-5	E	100	25	R	4.88	0.23700	0.6580	0.895	0.200	< 2	NA	6.3	24.3	343.0	575.0
J	3-Oct-05	DP-6	E	100	25	L	4.88	3.79000	0.4890	4.279	2.290	< 2	NA	6.4	23.8	298.0	346.0
K	23-May-05	BG-1	F	-25	0	C	5.85	0.02000	0.1870	0.207	0.337	< 2	NA	7.0	20.7	229.0	48.7
K	23-May-05	DP-1	C	23	7	L	5.85	25.20000	0.4990	25.699	0.212	< 2	NA	7.1	19.6	709.0	68.4
K	23-May-05	DP-2	D	68	6	R	5.85	1.53000	***0.0050***	1.530	0.234	< 2	NA	6.6	19.5	80.1	8.7
K	23-May-05	DP-3	D	63	5	L	5.85	11.30000	0.5450	11.845	7.510	< 2	NA	6.0	20.2	454.0	80.8
K	23-May-05	DP-4	D	76	43	R	5.85	0.05700	0.0850	0.142	0.708	< 2	NA	6.1	20.3	226.0	41.1
K	23-May-05	DP-5	D	73	25	R	5.85	8.77000	0.5190	9.289	0.475	< 2	NA	5.9	19.8	587.0	107.2
K	23-May-05	DP-6	E	100	0	C	5.85	0.02850	***0.0050***	0.029	0.119	< 2	NA	5.9	19.9	81.2	14.9

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*** Labs 1=Trident, 2=SCDHEC. NA=Not Analyzed. NR=Not Reported.

Table 3. Summary of Field and Analytical Water Quality Results
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

Site	Date Sampled	Sample ID	Sampling Zone *	Distance from System Edge along Center Line (ft)	Distance Offset from Center Line (ft)	Direction of Offset from Center Line	Ground-water Depth (ft below TOC)	NO_3/NO_2 (mg/L) **	TKN (mg/L) **	TN (mg/L)	TP (mg/L) **	Fecal Coliforms (c/100ml) ***		pH	Temp (°C)	Specific Conductivity	Chloride
												Lab1	Lab2				
L	25-Oct-05	BG-1	F	-100	125	L	3.66	1.24000	0.2920	1.532	0.101	< 2	NA	6.1	22.4	1257.0	17.9
L	25-Oct-05	DP-1	C	20	25	R	3.66	2.43000	2.7900	5.220	7.820	< 2	NA	6.0	23.0	1475.0	417.0
L	25-Oct-05	DP-2	C	20	0	C	3.66	2.76000	1.6600	4.420	7.270	< 2	NA	6.1	23.4	1543.0	473.0
L	25-Oct-05	DP-3	C	20	25	L	3.66	2.62000	1.6900	4.310	4.600	< 2	NA	6.2	22.9	1488.0	350.0
L	25-Oct-05	DP-4	C	30	25	R	3.66	5.55000	1.5200	7.070	7.280	< 2	NA	6.0	22.5	1562.0	542.0
L	25-Oct-05	DP-5	C	30	0	C	3.66	5.66000	1.4400	7.100	6.920	< 2	NA	6.0	22.3	1750.0	620.0
L	25-Oct-05	DP-6	C	30	25	L	3.66	5.20000	1.7400	6.940	8.260	< 2	NA	6.1	22.2	1647.0	510.0
L	25-Oct-05	DP-7	A	3	0	C	3.66	8.44000	3.1800	11.620	1.330	< 2	< 2	6.2	21.1	1849.0	717.0
L	25-Oct-05	DP-8	B	10	5	L	3.66	0.54300	2.3300	2.873	6.050	< 2	< 2	6.3	22.6	1044.0	205.0
L	25-Oct-05	DP-9	B	10	5	R	3.66	1.98000	1.3200	3.300	4.560	< 2	< 2	6.0	22.9	1361.0	346.0
M	27-Oct-05	BG-1	F	-26	64	L	3.00	***0.00850***	0.3240	0.324	4.910	< 2	NA	5.8	23.4	84.1	1.8
M	27-Oct-05	DP-1	C	25	0	C	3.00	8.12000	0.4550	8.575	2.750	< 2	NA	5.9	23.4	129.4	2.7
M	27-Oct-05	DP-2	D	50	25	R	3.00	11.00000	0.1360	11.136	0.791	< 2	NA	5.3	23.8	147.4	4.8
M	27-Oct-05	DP-3	D	50	0	C	3.00	15.20000	1.0100	16.210	9.540	< 2	NA	5.2	24.2	205.1	11.5
M	27-Oct-05	DP-4	D	50	25	L	3.00	5.81000	0.4810	6.291	1.620	< 2	NA	5.5	23.0	123.0	7.0
M	27-Oct-05	DP-5	E	100	10	R	3.00	0.29400	0.1420	0.436	1.920	< 2	NA	5.5	24.4	58.3	2.9
M	27-Oct-05	DP-6	E	100	25	L	3.00	3.72000	0.5360	4.256	2.890	< 2	NA	5.4	24.1	92.1	2.7
M	27-Oct-05	DP-7	A	3	0	C	3.00	20.00000	1.6200	21.620	1.270	< 2	< 2	5.5	24.3	352.0	28.7
M	27-Oct-05	DP-8	B	10	5	R	3.00	0.35100	0.4170	0.768	2.330	< 2	< 2	5.5	24.3	143.0	3.8
M	27-Oct-05	DP-9	B	10	5	L	3.00	14.80000	0.5700	15.370	1.780	< 2	< 2	5.4	24.5	316.0	38.2
N	24-May-05	BG-1	F	-60	15	L	5.28	***0.00150***	0.0170	0.017	1.530	< 2	NA	6.9	18.1	69.3	20.8
N	24-May-05	DP-1	C	20	0	C	5.28	17.20000	0.7510	17.951	0.267	< 2	NA	6.7	18.6	452.0	71.5
N	24-May-05	DP-2	D	50	25	R	5.28	28.50000	0.2930	28.793	0.380	< 2	NA	5.6	18.6	482.0	80.7
N	24-May-05	DP-3	D	50	0	C	5.28	31.30000	0.5990	31.899	0.421	< 2	NA	5.8	18.7	560.0	116.8
N	24-May-05	DP-4	D	50	25	L	5.28	9.57000	0.5930	10.163	0.480	< 2	NA	5.7	19.3	340.0	84.6
N	24-May-05	DP-5	E	100	25	R	5.28	1.52000	0.4930	2.013	0.493	< 2	NA	5.3	20.0	161.0	43.6
N	24-May-05	DP-6	E	100	25	L	5.28	***0.00150***	0.4110	0.411	0.952	< 2	NA	5.9	19.4	101.8	26.0

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Table 3. Summary of Field and Analytical Water Quality Results
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

Site	Date Sampled	Sample ID	Sampling Zone *	Distance from System Edge along Center Line (ft)	Distance Offset from Center Line (ft)	Direction of Offset from Center Line	Ground-water Depth (ft below TOC)	NO_3/NO_2 (mg/L) **	TKN (mg/L) **	TN (mg/L)	TP (mg/L) **	Fecal Coliforms (c/100ml) ***		pH	Temp (°C)	Specific Conductivity	Chloride
												Lab1	Lab2				
O	23-Sep-05	BG-1	F	NA	NA	NA	5.51	***0.00850***	0.0180	0.018	0.071	< 2	NA	7.2	27.7	170.0	86.8
O	23-Sep-05	DP-1	D	50	0	C	5.51	0.81300	***0.0050***	0.813	1.400	< 2	NA	7.9	23.1	984.0	752.0
O	23-Sep-05	DP-2	D	75	25	R	5.51	0.17400	0.6300	0.804	0.349	< 2	NA	7.3	23.8	935.0	762.0
O	23-Sep-05	DP-3	D	75	0	C	5.51	0.15600	0.0120	0.168	0.748	< 2	NA	7.4	24.3	951.0	770.0
O	23-Sep-05	DP-4	D	75	25	L	5.51	0.12800	0.1120	0.240	1.580	< 2	NA	7.3	24.1	938.0	758.0
O	23-Sep-05	DP-5	E	100	25	R	5.51	0.94900	0.2010	1.150	0.548	50	NA	7.4	24.5	1010.0	709.0
O	23-Sep-05	DP-6	E	100	25	L	5.51	0.96000	0.1670	1.127	0.258	13	NR	7.5	25.1	997.0	715.0
O	23-Sep-05	DP-7	A	3	0	C	5.51	***0.00850***	1.1900	1.190	1.680	< 2	NR	7.3	29.7	2430.0	1328.0
O	23-Sep-05	DP-8	B	10	5	R	5.51	1.15000	1.2800	2.430	0.448	> 1600	NR	7.4	27.6	1860.0	990.0
P	4-May-05	BG-1	F	-44	72	L	5.97	0.02000	1.5300	1.550	18.200	< 2	NA	7.3	18.2	442.0	139.4
P	4-May-05	DP-1	A	5	0	C	5.97	20.40000	0.4440	20.844	0.731	< 2	NA	5.1	18.5	1259.0	850.0
P	4-May-05	DP-2	B	15	0	C	5.97	0.02000	0.1000	0.120	0.765	< 2	NA	5.3	18.0	264.0	64.9
P	4-May-05	DP-3	B	15	10	R	5.97	0.02000	0.1050	0.125	0.144	< 2	NA	5.3	18.4	294.0	117.2
P	4-May-05	DP-4	B	15	10	L	5.97	0.03300	0.3630	0.396	0.216	< 2	NA	5.3	18.6	1021.0	448.0
P	4-May-05	DP-5	C	25	0	R	5.97	0.02000	0.3060	0.326	2.460	< 2	NA	5.0	18.5	288.0	320.0
P	4-May-05	DP-6	C	25	25	L	5.97	0.02000	0.5140	0.534	2.520	< 2	NA	5.0	18.5	586.0	1698.0
Q	9-Jun-05	BG-1	F	-26	18	R	7.07	0.01760	0.0190	0.037	0.212	< 2	NA	5.7	20.7	156.8	34.1
Q	9-Jun-05	DP-1	C	25	0	C	7.07	36.60000	0.3850	36.985	0.117	< 2	NA	5.4	19.8	1424.0	443.0
Q	9-Jun-05	DP-2	D	65	0	C	7.07	0.08340	0.2710	0.354	0.128	< 2	NA	5.6	20.2	518.0	138.1
Q	9-Jun-05	DP-3	D	65	25	L	7.07	15.70000	0.4820	16.182	0.270	< 2	NA	5.5	20.3	1294.0	540.0
Q	9-Jun-05	DP-4	D	65	10	R	7.07	0.08950	0.0210	0.111	0.249	< 2	NA	6.0	20.2	183.4	2.2
Q	9-Jun-05	DP-5	E	100	25	L	7.07	8.34000	0.4450	8.785	1.510	< 2	NA	5.5	20.5	1085.0	394.0
Q	9-Jun-05	DP-6	E	100	25	R	7.07	0.00824	0.3920	0.400	0.443	< 2	NA	5.6	19.6	1031.0	426.0

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Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

Site	Date Sampled	Sample ID	Sampling Zone *	Distance from System Edge along Center Line (ft)	Distance Offset from Center Line (ft)	Direction of Offset from Center Line	Ground-water Depth (ft below TOC)	NO_3/NO_2 (mg/L) **	TKN (mg/L) **	TN (mg/L)	TP (mg/L) **	Fecal Coliforms (c/100ml) ***		pH	Temp (°C)	Specific Conductivity	Chloride
												Lab1	Lab2				
R	12-Oct-05	BG-1	F	NA	NA	NA	8.41	0.17600	0.6880	0.864	2.170	< 2	NA	4.8	23.5	71.2	4.1
R	12-Oct-05	DP-1	C	18	0	C	8.41	1.42000	5.1000	6.520	3.230	< 2	NA	5.6	22.3	150.1	17.7
R	12-Oct-05	DP-2	C	25	25	R	8.41	2.59000	0.7740	3.364	5.540	< 2	NA	5.2	22.4	163.8	19.6
R	12-Oct-05	DP-3	C	25	0	C	8.41	2.95000	1.3500	4.300	10.100	< 2	NA	5.0	22.7	182.5	20.9
R	12-Oct-05	DP-4	C	25	25	L	8.41	2.81000	0.5520	3.362	3.960	< 2	NA	5.4	22.9	188.3	20.3
R	12-Oct-05	DP-5	D	70	25	R	8.41	4.93000	0.4100	5.340	0.848	< 2	NA	5.9	21.9	186.2	14.9
R	12-Oct-05	DP-6	D	70	25	L	8.41	4.72000	0.0860	4.806	0.332	< 2	NA	6.0	21.7	178.5	15.2
R	12-Oct-05	DP-7	A	3	0	C	8.41	0.43600	6.6600	7.096	0.172	< 2	8	7.3	23.0	548.0	53.0
R	12-Oct-05	DP-8	B	10	5	R	8.41	1.18000	3.8800	5.060	0.650	< 2	< 2	6.6	23.4	188.0	16.8
R	12-Oct-05	DP-9	B	10	5	L	8.41	1.70000	1.4700	3.170	1.480	< 2	< 2	6.4	23.1	152.0	15.4
S	26-Oct-05	BG-1	F	-215	68	L	8.38	***0.00850***	0.4920	0.492	0.090	< 2	NA	4.4	20.9	95.9	6.0
S	26-Oct-05	DP-1	C	25	0	C	8.38	3.23000	0.4050	3.635	0.073	< 2	NA	5.6	20.6	1151.0	264.0
S	26-Oct-05	DP-2	D	50	25	R	8.38	0.95600	0.3520	1.308	0.087	< 2	NA	4.9	20.3	1001.0	383.0
S	26-Oct-05	DP-3	D	50	0	C	8.38	0.97800	0.2420	1.220	0.077	< 2	NA	4.5	20.6	1013.0	427.0
S	26-Oct-05	DP-4	D	50	25	L	8.38	1.01000	0.1860	1.196	0.031	< 2	NA	4.8	20.2	978.0	244.0
S	26-Oct-05	DP-5	E	100	25	R	8.38	***0.00850***	0.0800	0.080	0.188	< 2	NA	3.9	20.0	312.0	94.0
S	26-Oct-05	DP-6	E	100	25	L	8.38	***0.00850***	0.1110	0.111	0.177	< 2	NA	4.1	18.7	384.0	91.0
S	26-Oct-05	DP-7	A	3	0	C	8.38	3.60000	0.4450	4.045	0.169	< 2	< 2	5.8	18.7	752.0	165.0
S	26-Oct-05	DP-8	B	10	5	L	8.38	7.90000	0.7490	8.649	0.581	< 2	< 2	6.0	20.1	1095.0	297.0
S	26-Oct-05	DP-9	B	10	5	R	8.38	6.40000	1.0400	7.440	0.773	< 2	< 2	5.2	19.7	1003.0	283.0
T	22-Nov-05	BG-1	F	-100	155	L	1.59	***0.00850***	5.4200	5.420	3.750	< 2	NA	5.6	20.9	152.9	24.6
T	22-Nov-05	DP-1	C	25	0	C	1.59	0.02940	1.3500	1.379	2.760	< 2	NA	3.6	19.9	126.2	15.8
T	22-Nov-05	DP-2	D	50	25	R	1.59	***0.00850***	0.9800	0.980	2.100	< 2	NA	3.9	19.8	174.9	27.1
T	22-Nov-05	DP-3	D	50	0	C	1.59	0.04320	0.7520	0.795	1.890	< 2	NA	3.3	20.4	281.0	84.4
T	22-Nov-05	DP-4	D	50	25	L	1.59	0.03920	0.1660	0.205	0.176	< 2	NA	3.8	20.5	148.0	38.8
T	22-Nov-05	DP-5	E	100	10	R	1.59	***0.00850***	1.1500	1.150	1.730	< 2	NA	4.4	21.2	65.0	28.3
T	22-Nov-05	DP-6	E	100	25	L	1.59	***0.00850***	0.6060	0.606	0.878	< 2	NA	4.1	22.5	170.1	32.3

* Zone A=3-5 ft from OSWS, B=10-15, C=18-40, D=45-76, E=100-135, F=bckgrnd.
** Italicized bold = half detection limits for "ND" or non-detects.
*** Labs 1=Trident, 2=SCDHEC. NA=Not Analyzed. NR=Not Reported.

Table 4. Summary Statistics for Downgradient Water Quality Samples
Onsite Wastewater Systems Assessment Program
Groundwater Assessment Study
Lowcountry Sites -- Charleston County
SCDHEC Project J04-N058-MJ

		NO_3/NO_2 (mg/L)				TKN (mg/L)				TN (mg/L)				TP (mg/L)				pH				Temperature (°C)				Specific Conductivity				Chloride			
Site	n*	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
A	6	0.31	0.35	0.03	0.75	0.64	0.82	0.10	2.02	0.95	0.76	0.13	2.05	0.40	0.42	0.07	1.22	6.18	0.19	5.9	6.4	24.2	0.4	23.5	24.5	99.6	15.5	88.1	127.3	6.2	1.7	4.0	9.2
B	6	2.46	2.35	0.01	6.15	0.24	0.18	0.01	0.46	2.70	2.49	0.01	6.58	0.12	0.16	0.04	0.44	6.78	0.26	6.4	7.0	22.0	1.6	20.0	24.8	453.5	201.5	212.0	716.0	76.0	26.8	40.2	109.7
C	6	11.82	10.19	0.02	30.30	0.81	0.52	0.03	1.63	12.63	10.45	0.04	31.17	0.59	0.74	0.08	2.06	6.50	0.37	5.9	7.0	19.4	0.7	18.7	20.7	634.7	353.1	96.0	1049.0	200.5	123.5	27.8	339.0
D	6	8.01	13.87	0.01	34.20	0.23	0.26	0.07	0.75	8.24	14.10	0.07	34.95	0.02	0.01	0.01	0.04	5.83	0.48	5.4	6.6	15.9	0.6	15.1	16.5	244.3	244.0	83.0	728.0	NA	NA	NA	NA
E	6	12.75	12.58	0.00	34.80	0.61	0.48	0.17	1.28	13.36	12.95	0.35	35.90	0.35	0.50	0.01	1.16	5.93	0.40	5.4	6.4	21.6	0.9	20.1	22.5	521.5	343.9	151.4	968.0	102.8	85.0	8.5	201.0
F	6	0.44	0.69	0.02	1.67	0.94	0.65	0.26	1.79	1.38	0.66	0.28	1.96	1.55	1.11	0.38	3.54	6.42	0.10	6.3	6.6	19.7	1.0	18.7	21.4	1293.3	1139.0	334.0	3130.0	1544.2	455.8	947.0	1999.0
G	6	7.00	12.61	0.02	32.50	0.17	0.10	0.10	0.36	7.17	12.58	0.38	32.62	2.40	3.78	0.32	10.00	5.78	0.12	5.7	6.0	19.9	0.7	19.1	20.7	284.8	289.7	53.6	759.0	43.1	33.6	20.5	97.3
H	6	8.34	12.18	1.41	33.10	0.48	0.48	0.17	1.42	8.82	12.24	1.63	33.67	3.67	2.06	2.15	7.69	6.22	0.70	5.4	7.4	18.4	0.4	17.9	19.0	167.7	218.0	52.9	610.0	10.9	24.7	0.4	61.3
I	6	9.03	4.67	4.38	14.70	0.53	0.16	0.37	0.83	9.57	4.71	4.94	15.43	1.02	0.98	0.20	2.78	5.98	0.13	5.8	6.2	20.4	0.5	19.7	21.3	386.7	95.7	302.0	514.0	42.4	13.4	27.5	58.9
J	6	1.99	2.35	0.19	5.90	1.14	1.62	0.12	4.02	3.43	2.08	0.90	6.02	5.51	6.53	0.20	17.70	6.88	0.63	6.3	7.9	24.4	0.5	23.8	25.1	353.2	182.1	171.0	703.0	309.5	152.7	148.0	575.0
K	6	7.81	9.75	0.03	25.20	0.28	0.27	0.01	0.55	8.09	9.97	0.03	25.70	1.54	2.93	0.12	7.51	6.27	0.48	5.9	7.1	19.9	0.3	19.5	20.3	356.2	266.9	80.1	709.0	53.5	38.7	8.7	107.2
L	9	3.91	2.45	0.54	8.44	1.96	0.65	1.32	3.18	5.87	2.69	2.87	11.62	6.01	2.19	1.33	8.26	6.10	0.11	6.0	6.3	22.5	0.7	21.1	23.4	1524.3	233.0	1044.0	1849.0	464.4	155.3	205.0	717.0
M	9	8.81	6.95	0.29	20.00	0.60	0.46	0.14	1.62	9.41	7.30	0.44	21.62	2.77	2.63	0.79	9.54	5.47	0.19	5.2	5.9	24.0	0.5	23.0	24.5	174.0	99.5	58.3	352.0	11.4	13.0	2.7	38.2
N	6	14.68	13.33	0.00	31.30	0.52	0.16	0.29	0.75	15.21	13.34	0.41	31.90	0.50	0.24	0.27	0.95	5.83	0.47	5.3	6.7	19.1	0.6	18.6	20.0	349.5	184.0	101.8	560.0	70.5	32.1	26.0	116.8
O	8	0.54	0.47	0.01	1.15	0.45	0.52	0.01	1.28	0.99	0.70	0.17	2.43	0.88	0.58	0.26	1.68	7.44	0.20	7.3	7.9	25.3	2.2	23.1	29.7	1263.1	565.9	935.0	2430.0	848.0	213.3	709.0	1328.0
P	6	3.42	8.32	0.02	20.40	0.31	0.17	0.10	0.51	3.72	8.39	0.12	20.84	1.14	1.08	0.14	2.52	5.17	0.15	5.0	5.3	18.4	0.2	18.0	18.6	618.7	427.4	264.0	1259.0	583.0	614.4	64.9	1698.0
Q	6	10.14	14.42	0.01	36.60	0.33	0.17	0.02	0.48	10.47	14.49	0.11	36.99	0.45	0.53	0.12	1.51	5.60	0.21	5.4	6.0	20.1	0.3	19.6	20.5	922.6	477.0	183.4	1424.0	323.9	207.0	2.2	540.0
R	9	2.53	1.54	0.44	4.93	2.25	2.37	0.09	6.66	4.78	1.40	3.17	7.10	2.92	3.27	0.17	10.10	5.93	0.74	5.0	7.3	22.6	0.6	21.7	23.4	215.3	125.7	150.1	548.0	21.5	12.0	14.9	53.0
S	9	2.68	2.85	0.01	7.90	0.40	0.31	0.08	1.04	3.08	3.15	0.08	8.65	0.24	0.26	0.03	0.77	4.98	0.74	3.9	6.0	19.9	0.7	18.7	20.6	854.3	307.4	312.0	1151.0	249.8	116.9	91.0	427.0
T	6	0.02	0.02	0.01	0.04	0.83	0.42	0.17	1.35	0.85	0.42	0.21	1.38	1.59	0.92	0.18	2.76	3.85	0.38	3.3	4.4	20.7	1.0	19.8	22.5	160.9	71.1	65.0	281.0	37.8	24.0	15.8	84.4

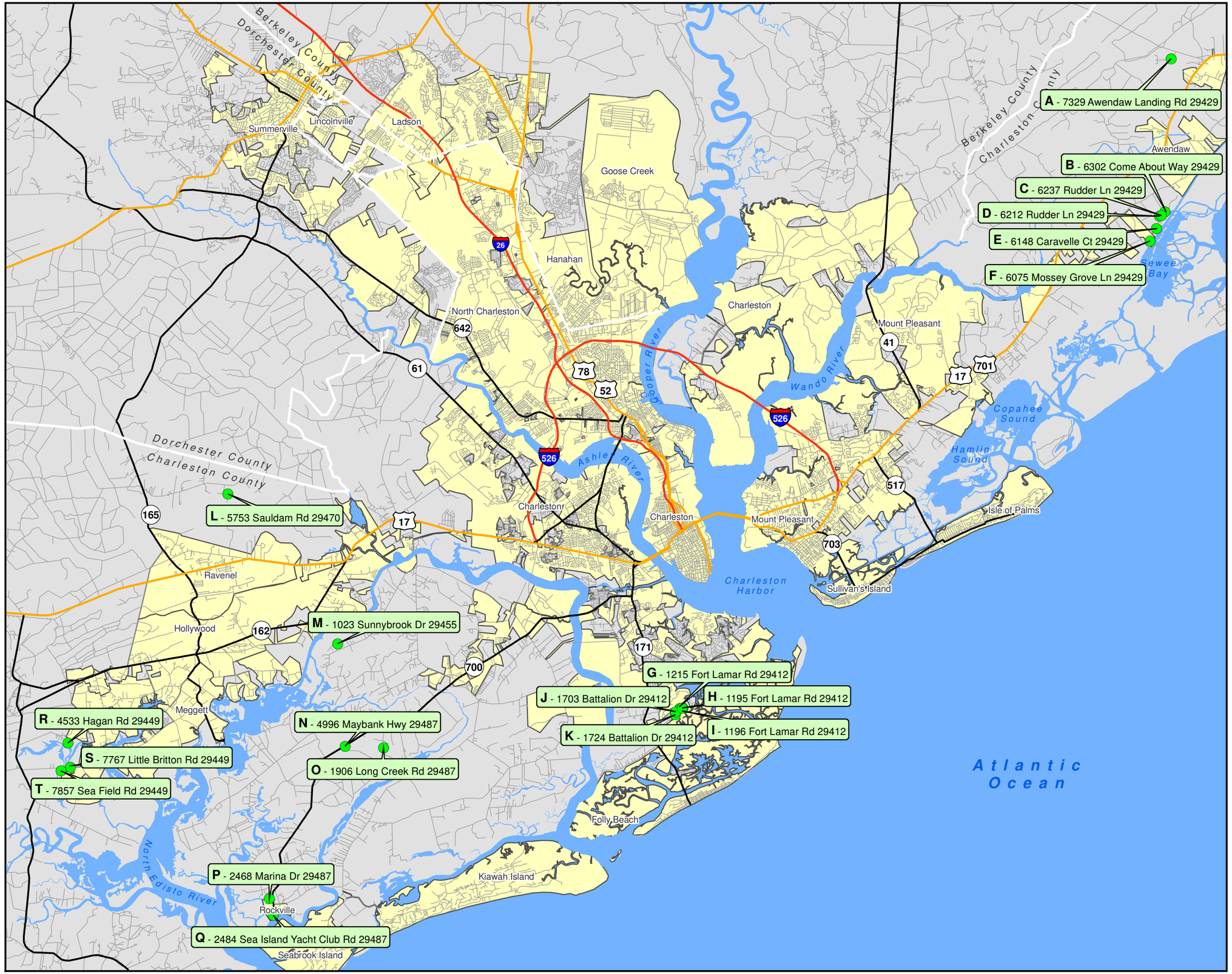
*** Values summarized in this table represent data from downgradient wells only. Background well data is not included in this statistical summary. See Table 3 for background values.**

Figure 1

SCDHEC Onsite Wastewater Systems Assessment Program

Lowcountry Site Locations

Charleston County



North Wind

General Engineering Laboratories

DHEC

PROMOTE PROTECT PROSPER

Date: February 23, 2006 Creator: SAS

Source: US Census; General Engineering Laboratories; North Wind

Pinsrv9\data\GIS\projects\DHEC_Coastal_DLH\projects\LocationMap.mxd

Figure 2A – Installation of temporary piezometer in residential yard using John Deere 6x4 Gator™ -mounted GeoProbe®.

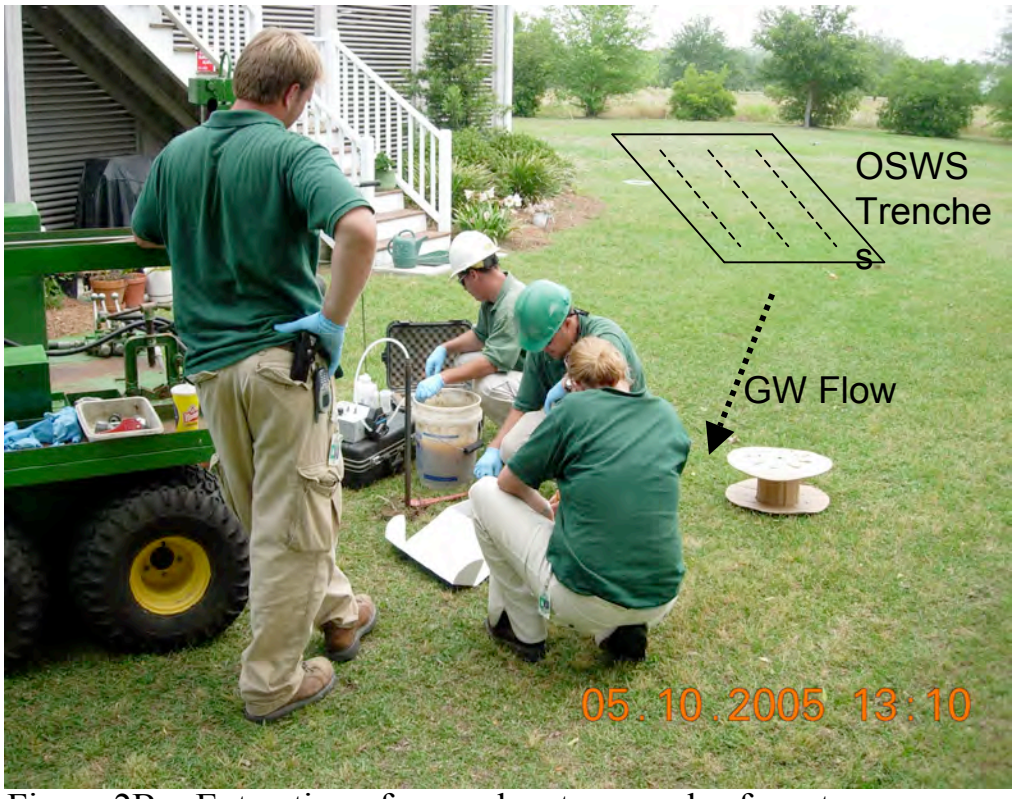


Figure 2B – Extraction of ground water samples from temporary well installed downgradient of OSWS (in upper right of scene). Groundwater flow is from upper right to lower center of scene.

Figure 2C – Extraction of groundwater samples from temporary well using peristaltic pump, and field parameter testing.

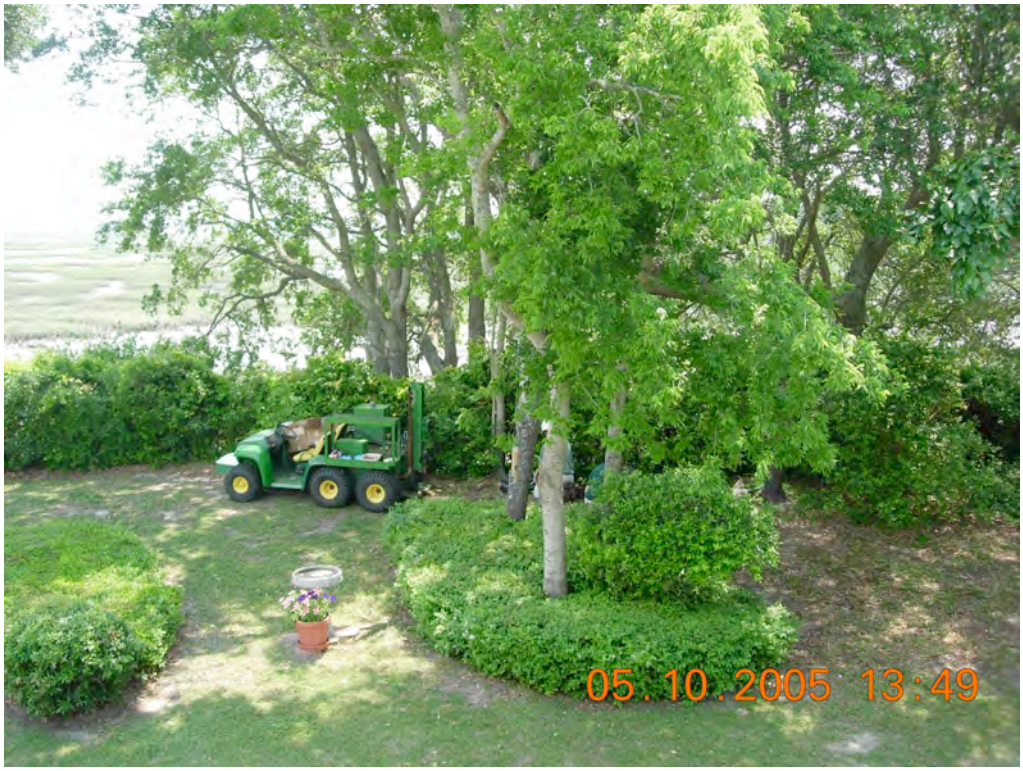


Figure 2D – Sampling rig with adjacent marsh. John's Island, Fort Lamar area. Note typical residential sampling obstacles.

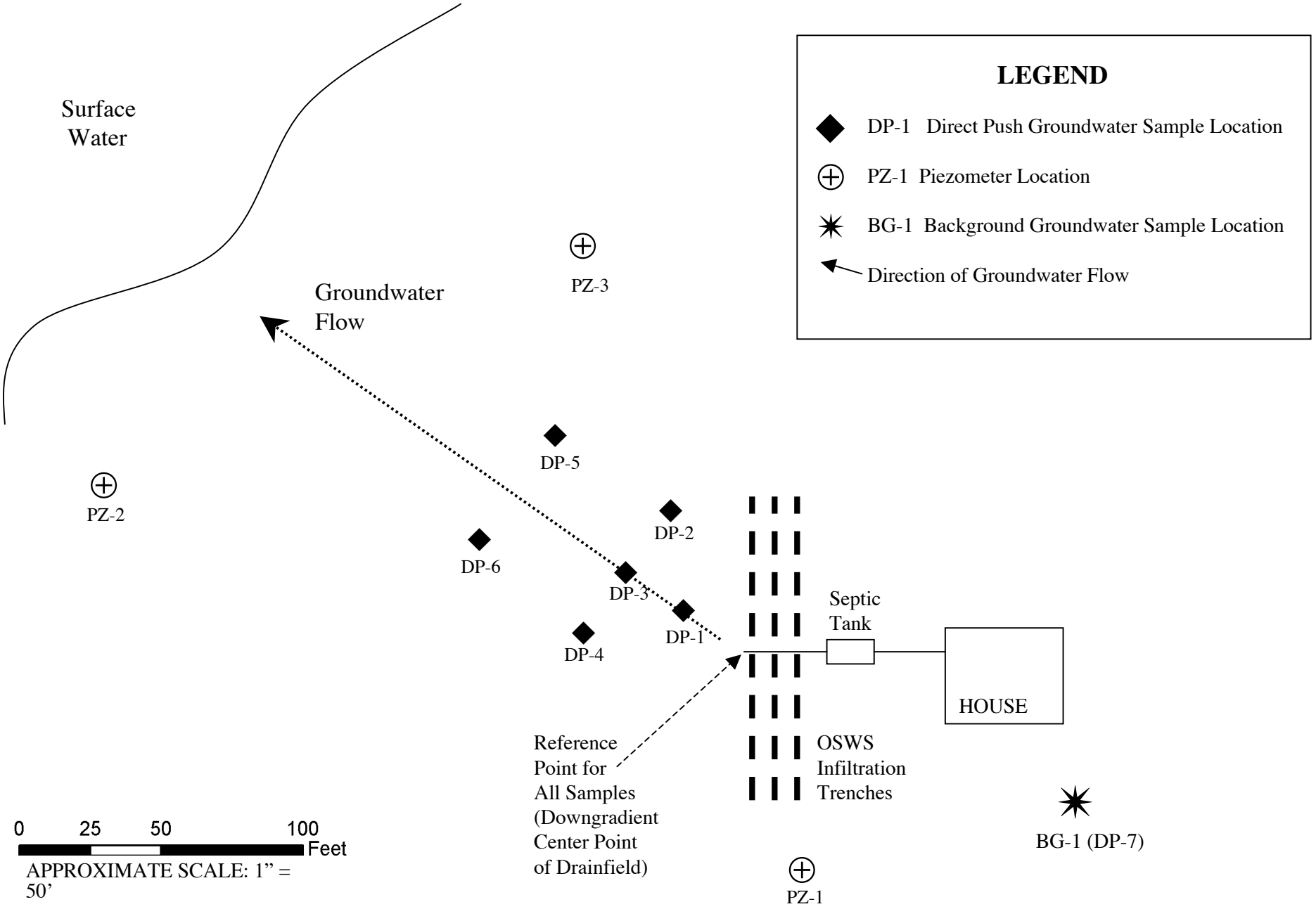


Figure 3. Idealized OSWS Groundwater Sampling Array

Figure 4. Spatial Distribution of Samples Collected, All 20 Sites, All Downgradient Samples, Relative to OSWS Reference Point

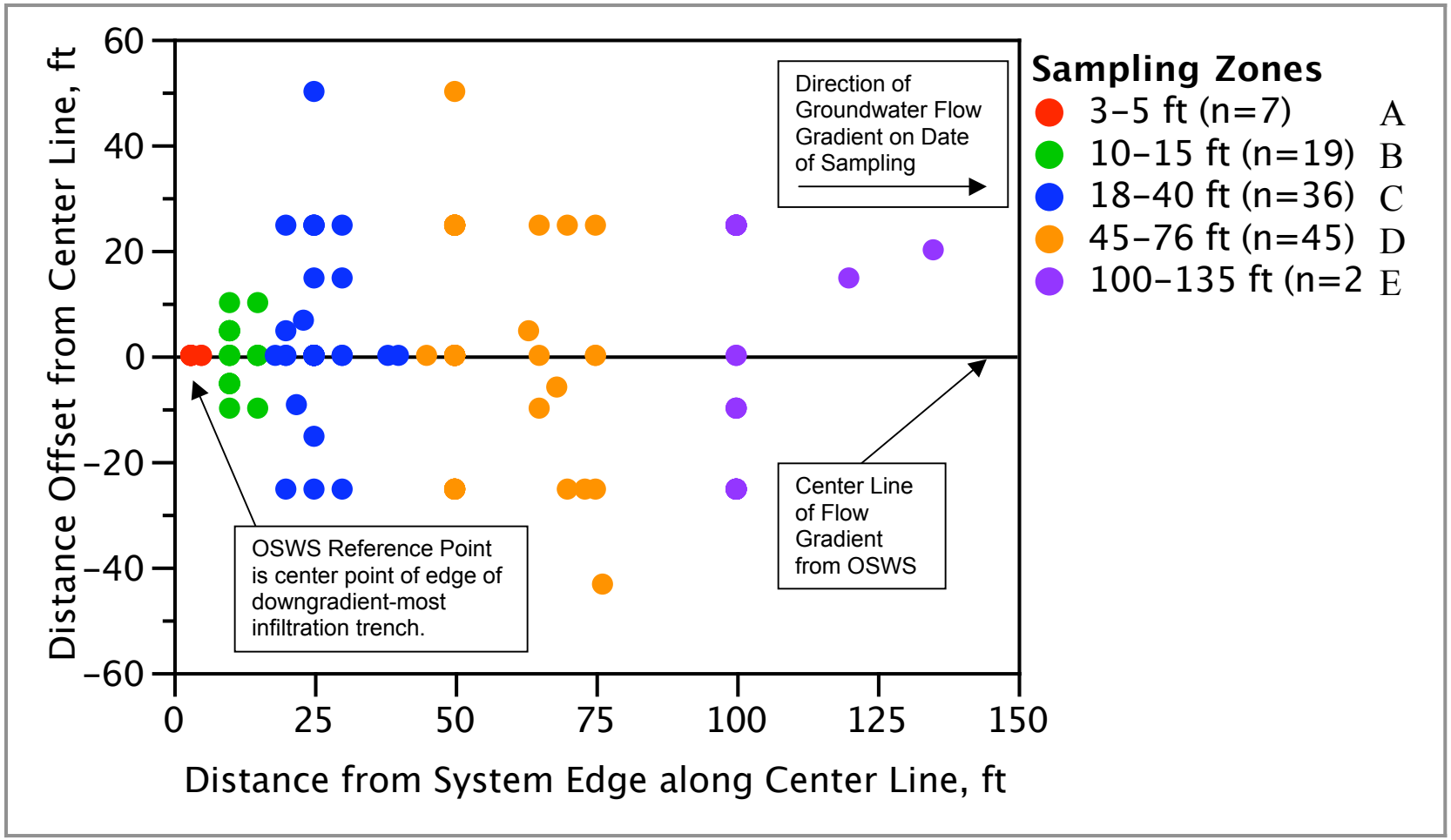


Figure 5A. Sampling Sites for System "A"

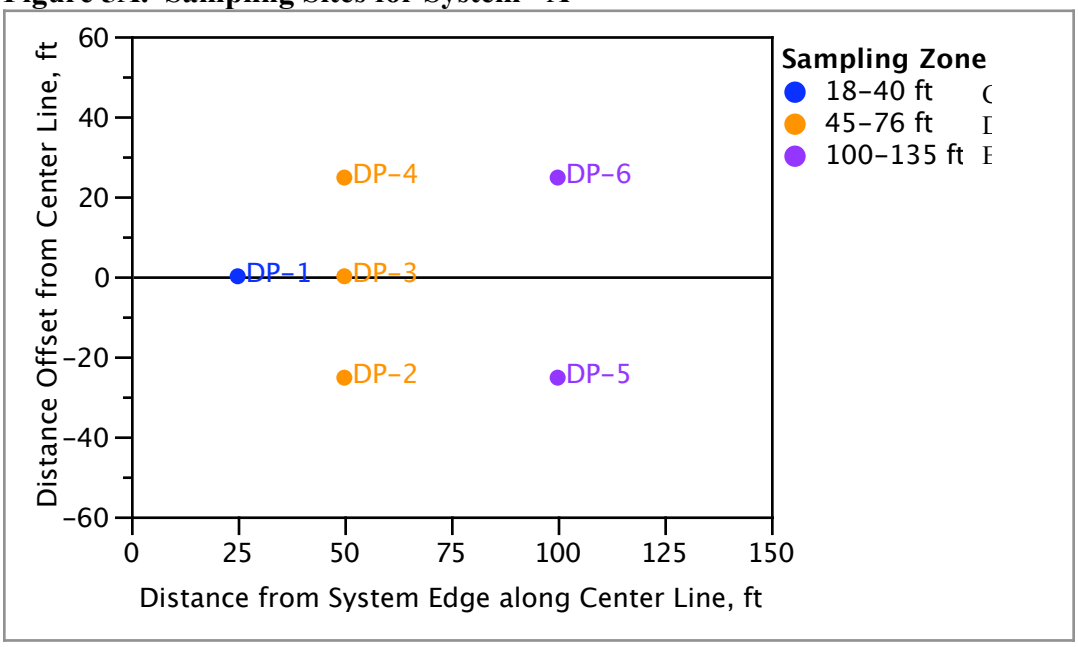


Figure 5B. Sampling Sites for System "B"

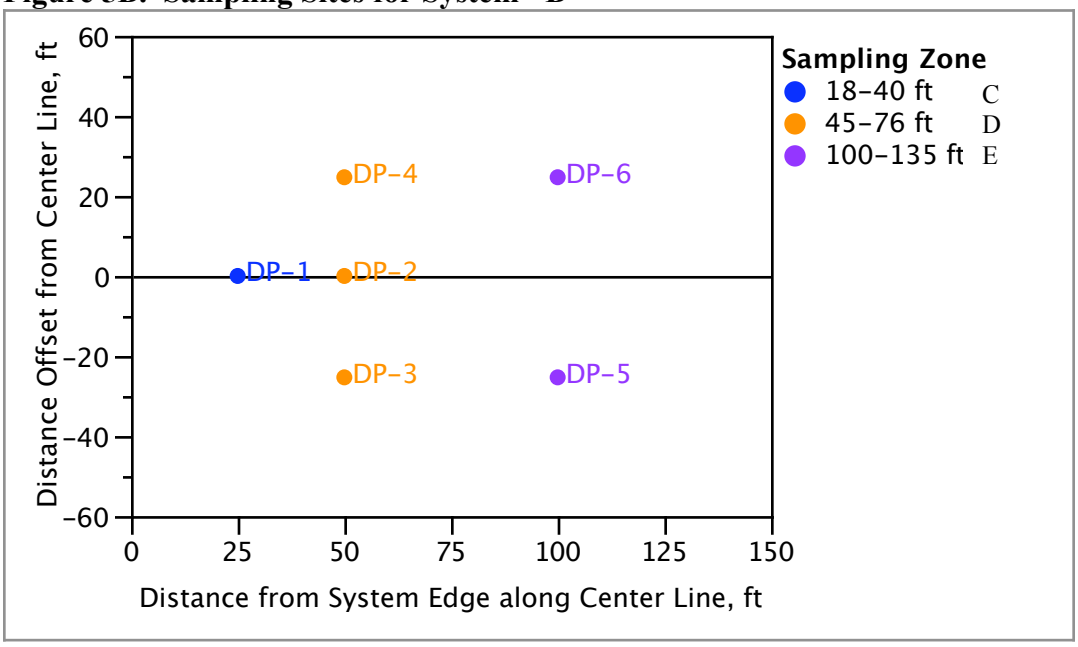


Figure 5C. Sampling Sites for System "C"

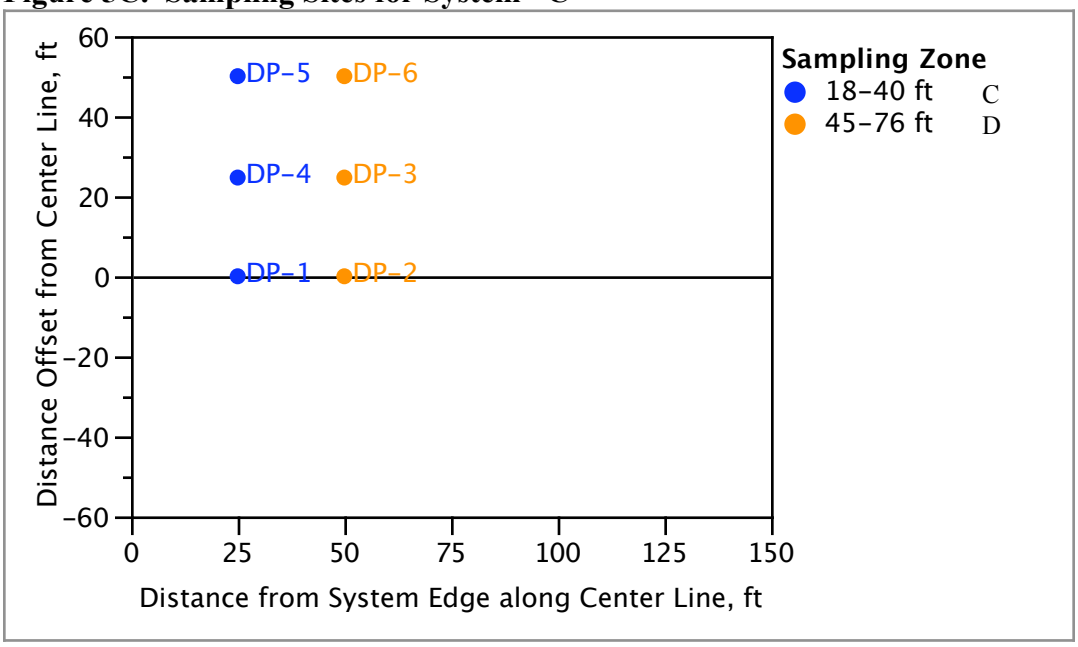


Figure 5D. Sampling Sites for System "D"

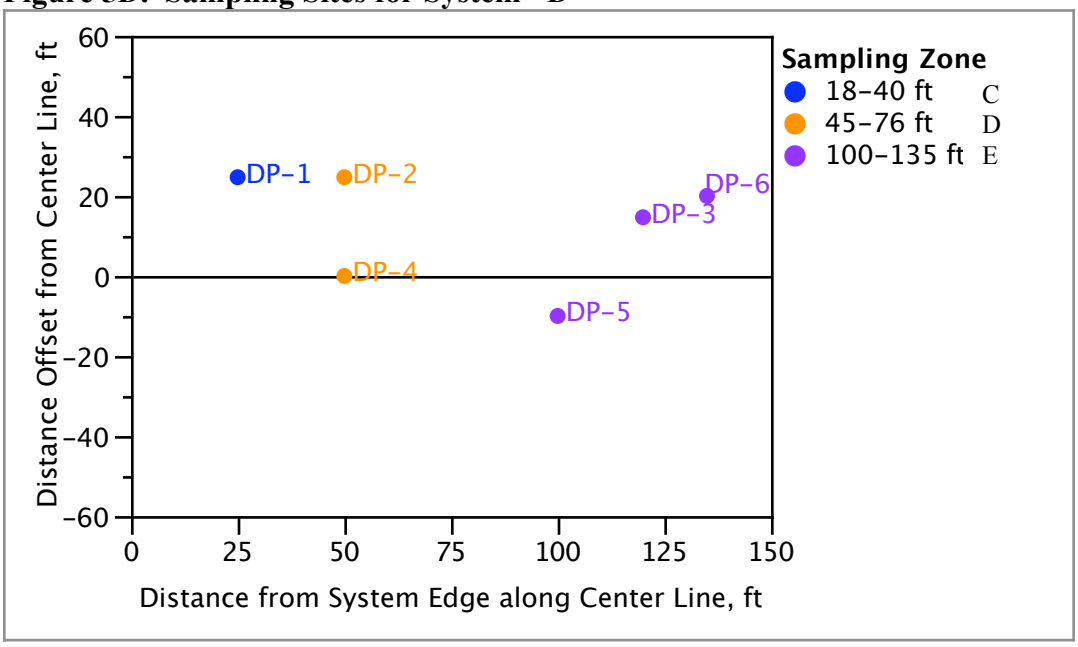


Figure 5E. Sampling Sites for System "E"

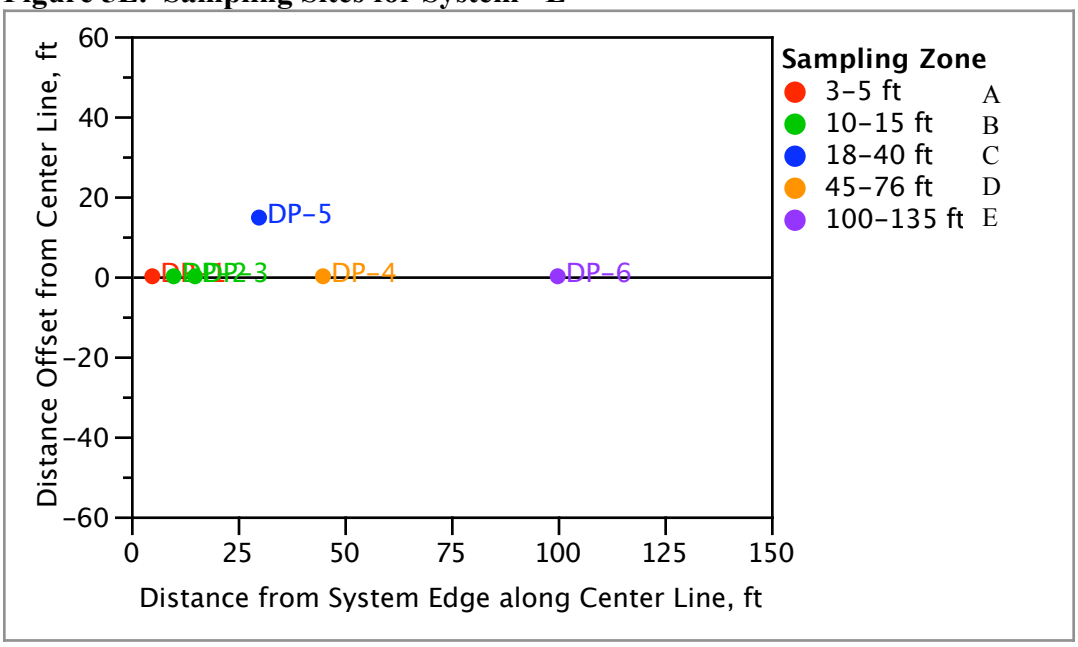


Figure 5F. Sampling Sites for System "F"

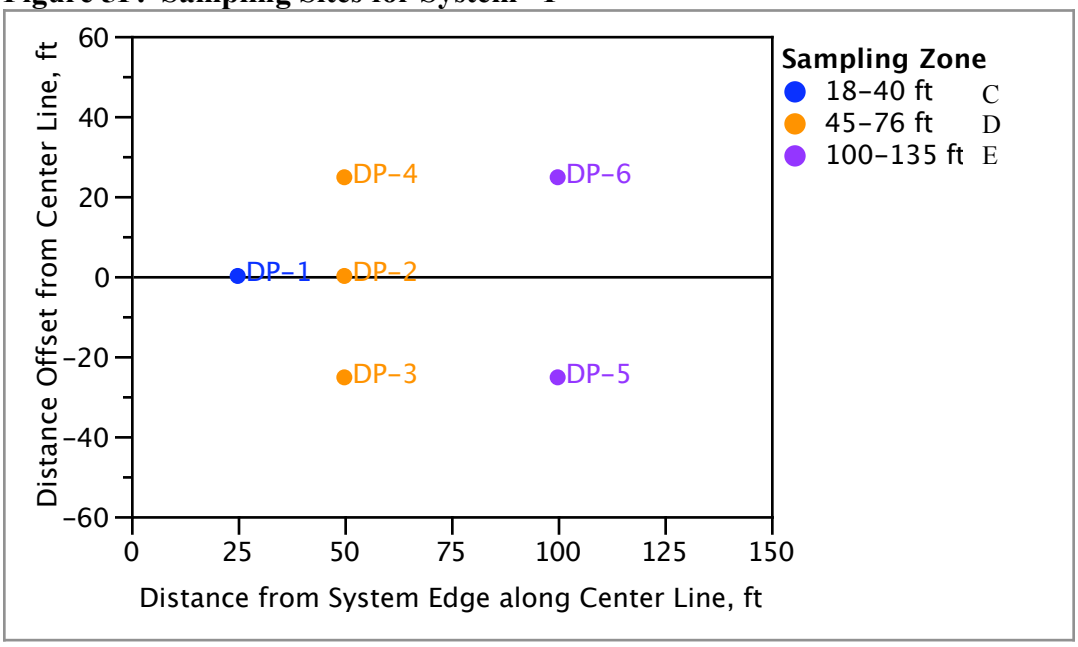


Figure 5G. Sampling Sites for System "G"

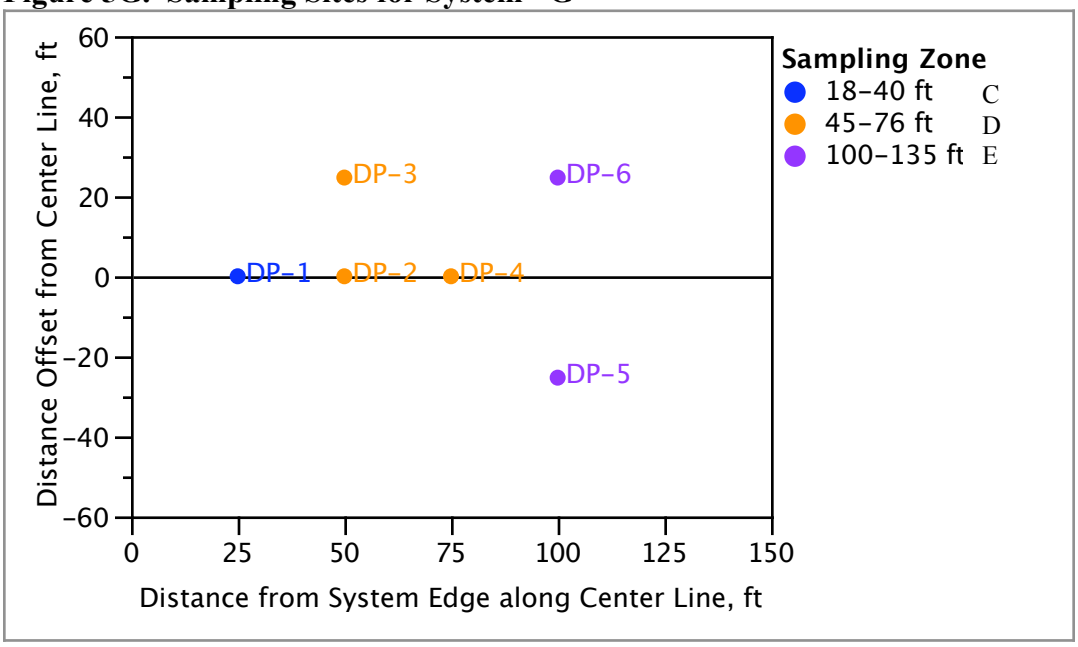


Figure 5H. Sampling Sites for System "H"

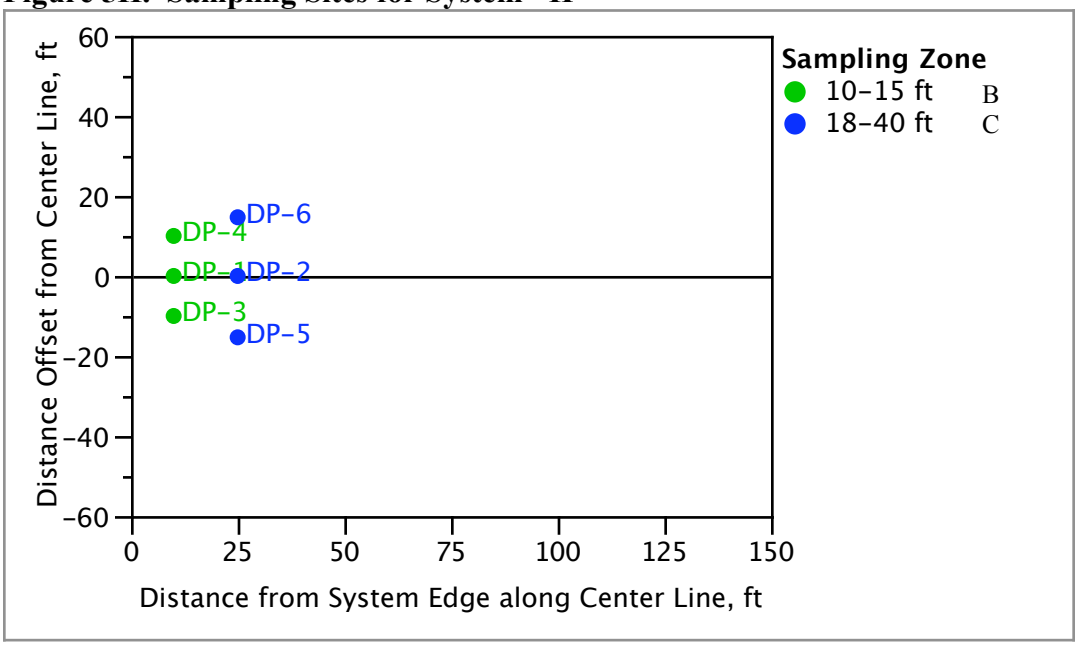


Figure 5I. Sampling Sites for System "I"

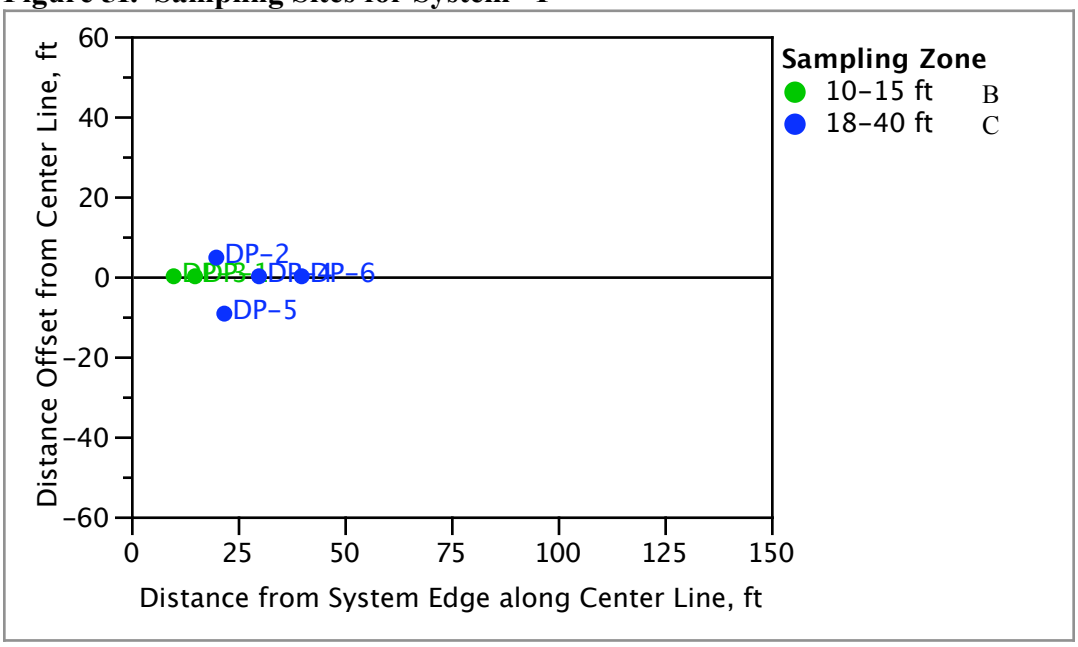


Figure 5J. Sampling Sites for System "J"

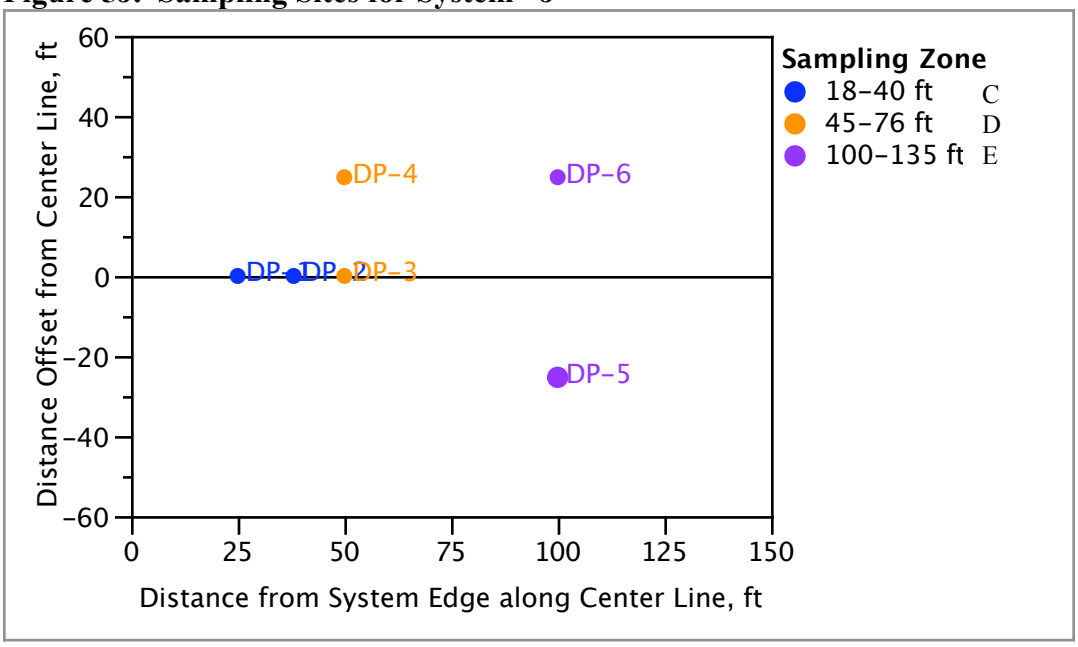


Figure 5K. Sampling Sites for System "K"

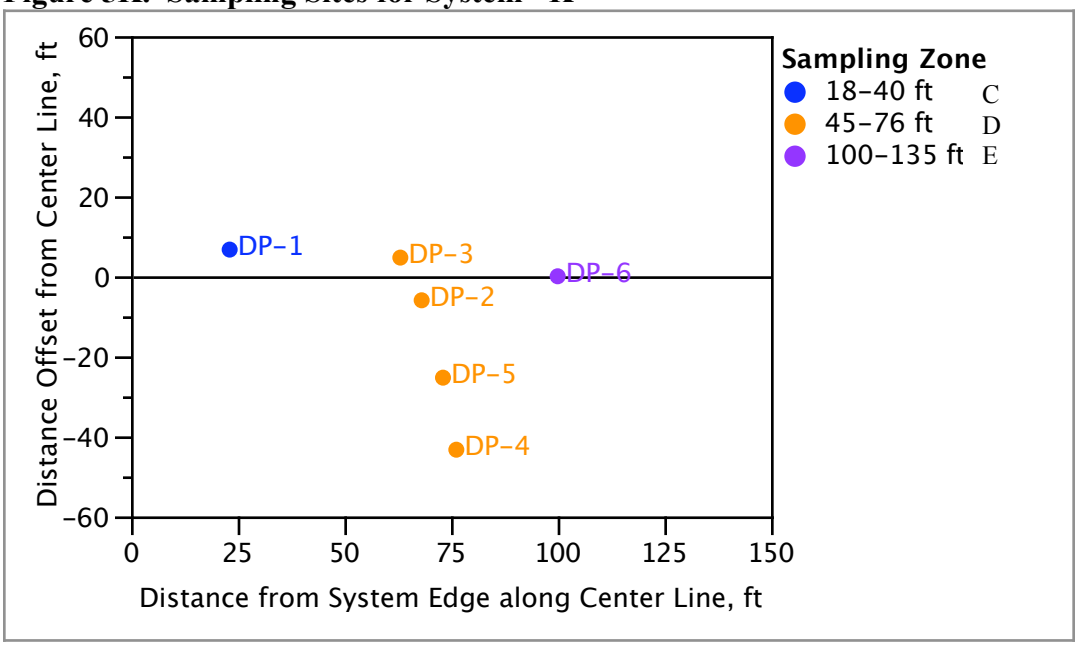


Figure 5L. Sampling Sites for System "L"

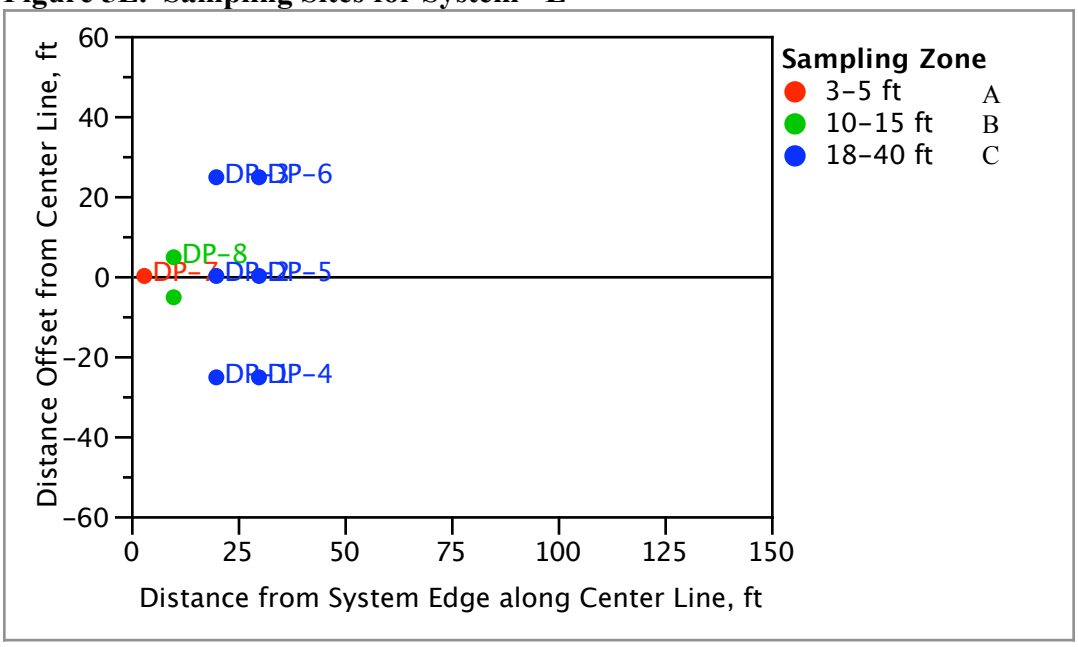


Figure 5M. Sampling Sites for System "M"

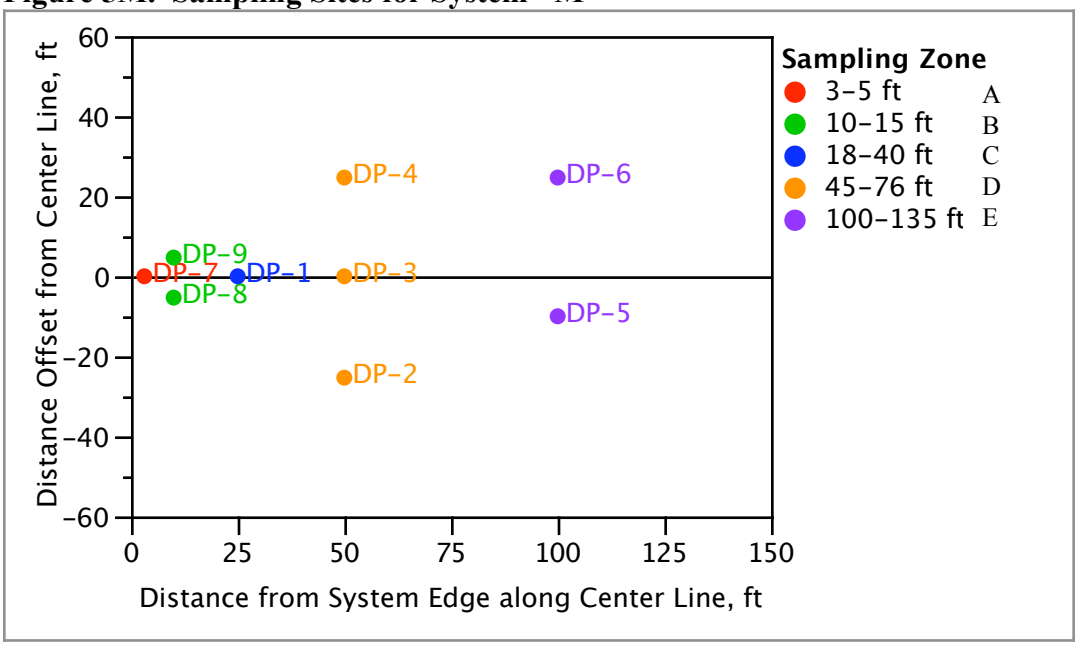


Figure 5N. Sampling Sites for System "N"

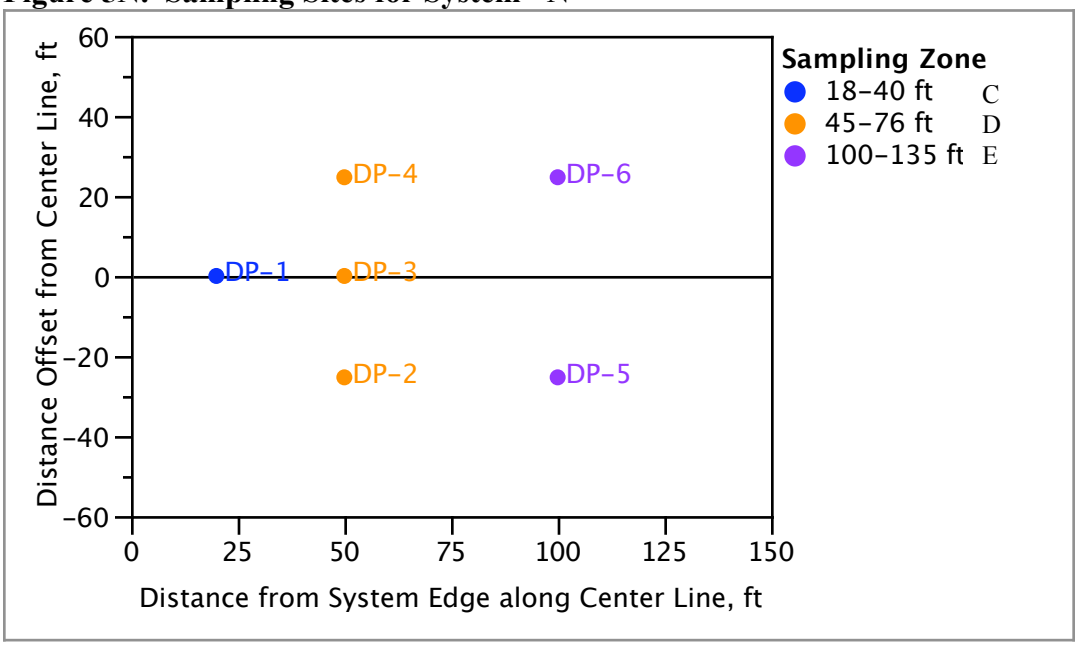


Figure 5O. Sampling Sites for System "O"

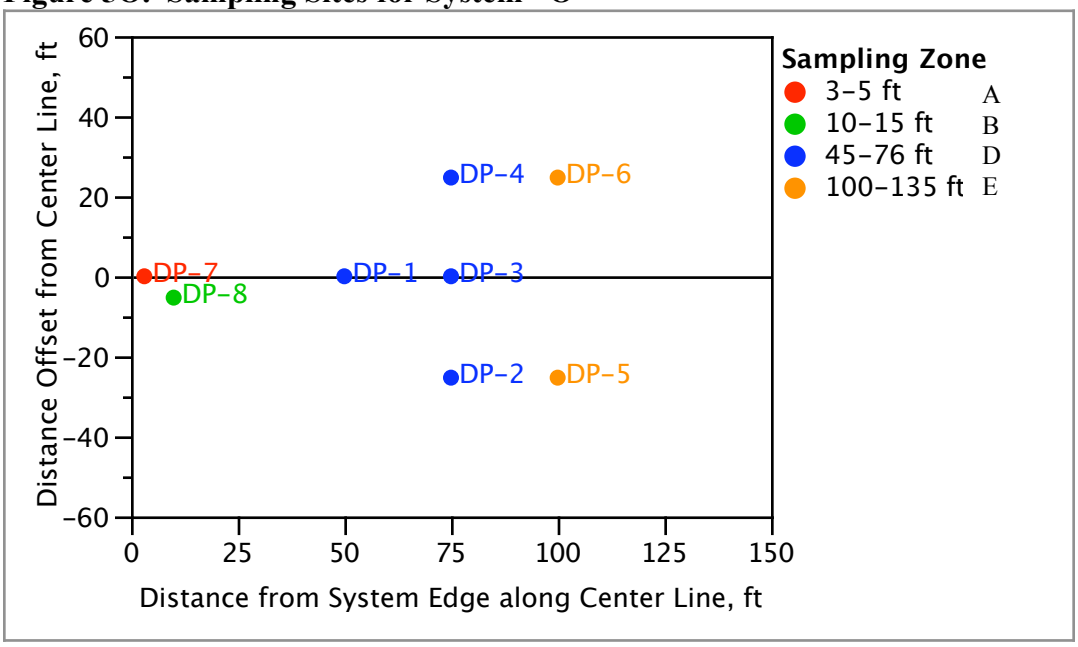


Figure 5P. Sampling Sites for System "P"

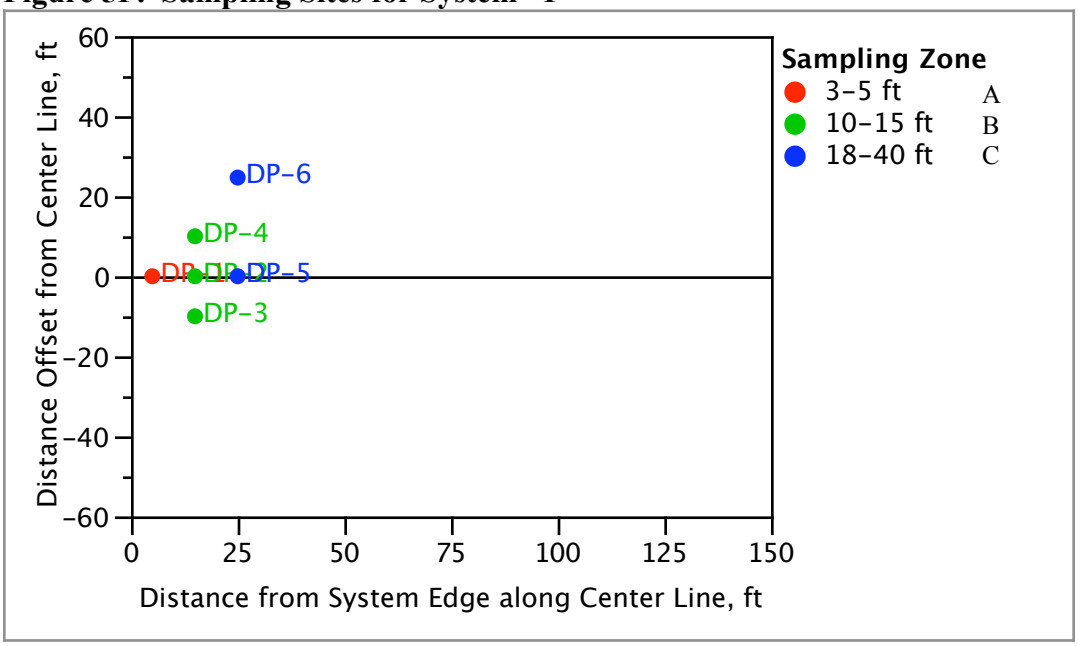


Figure 5Q. Sampling Sites for System "Q"

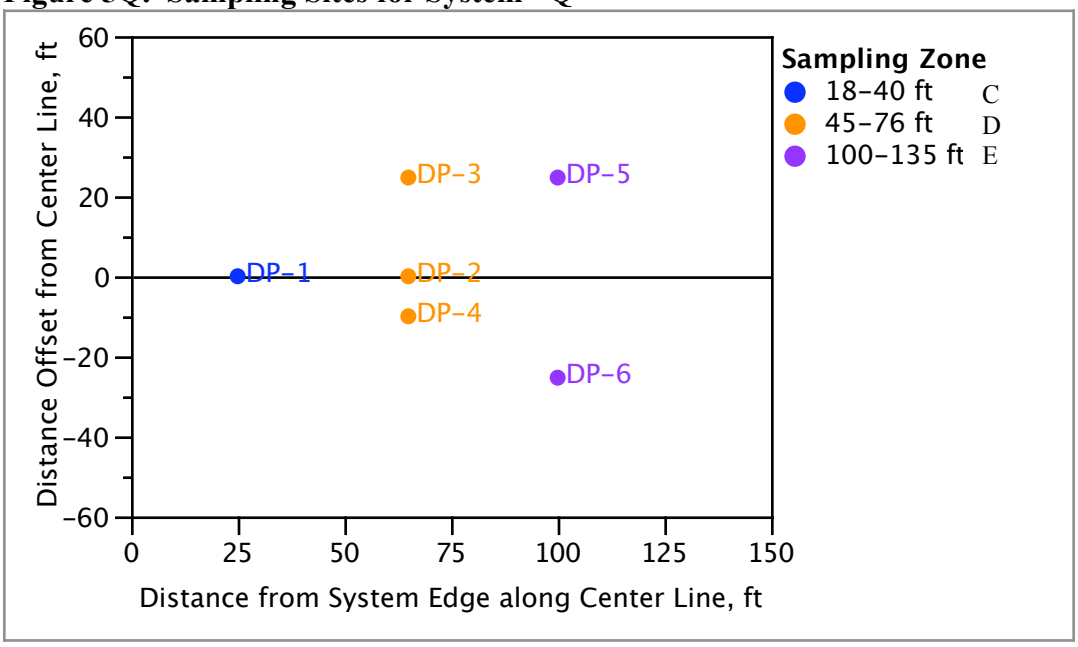


Figure 5R. Sampling Sites for System "R"

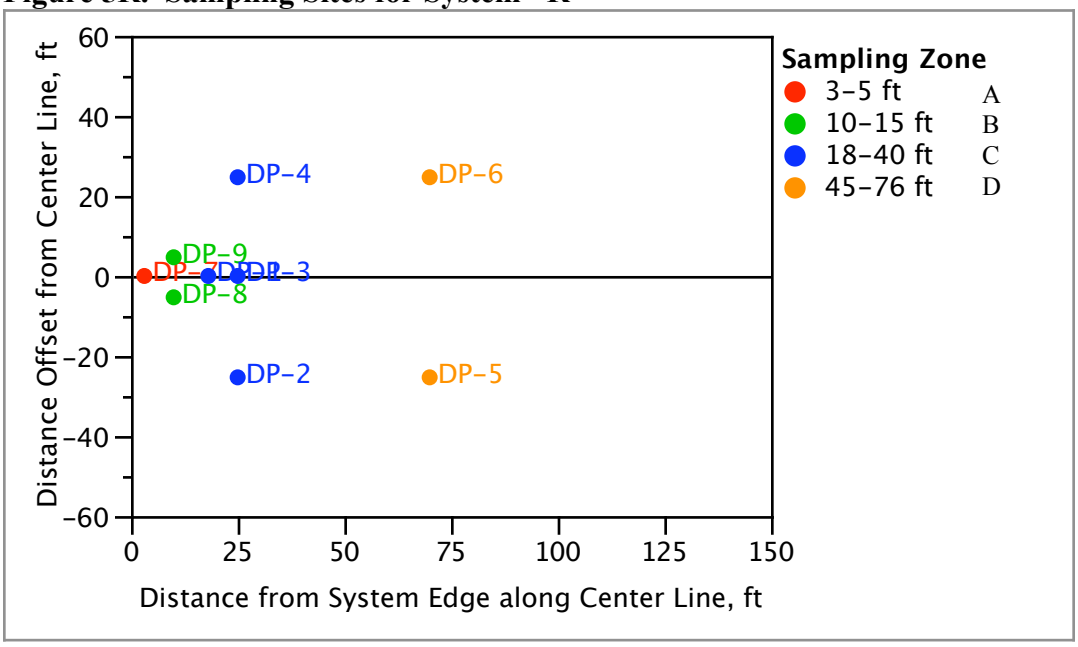


Figure 5S. Sampling Sites for System "S"

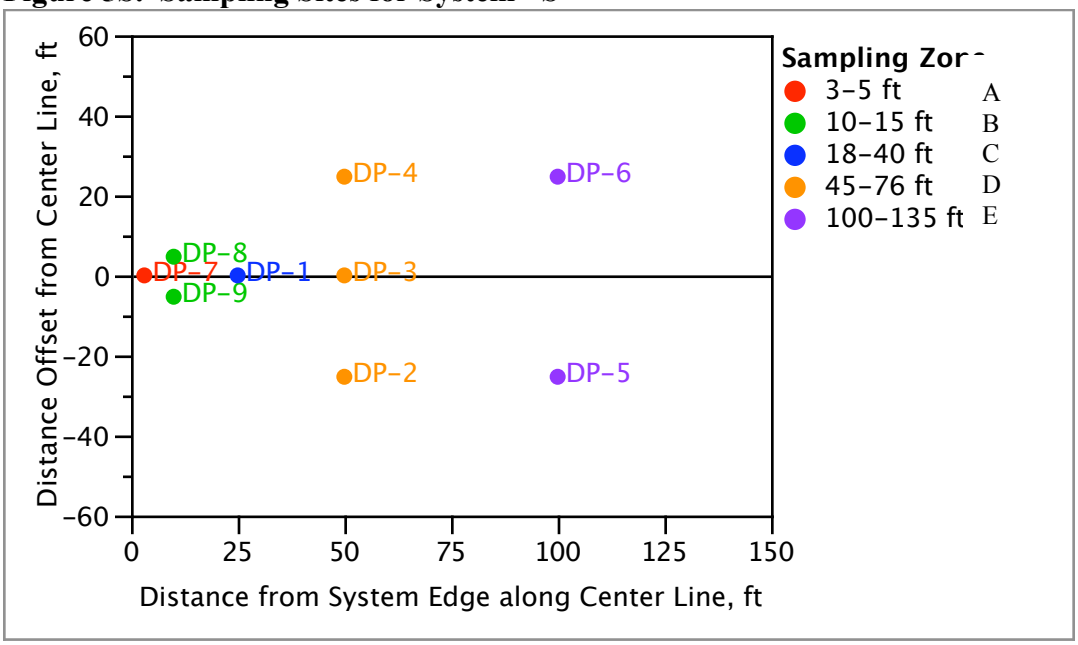
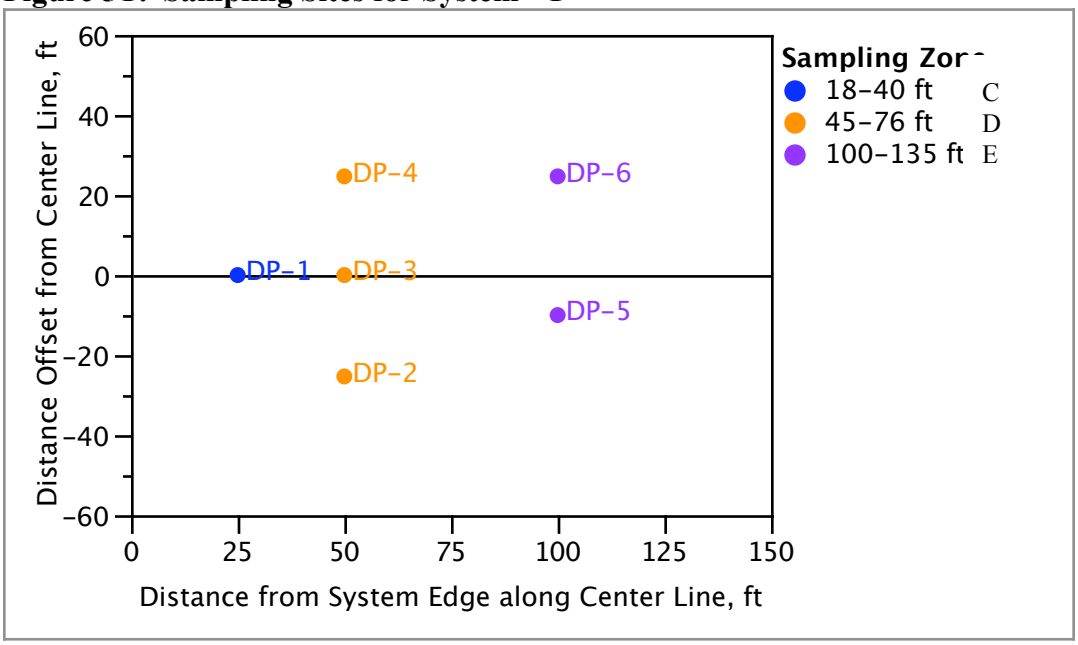


Figure 5T. Sampling Sites for System "T"



Combined Sampling Sites for 20 Systems, Showing Five Bands of Sampling Zones

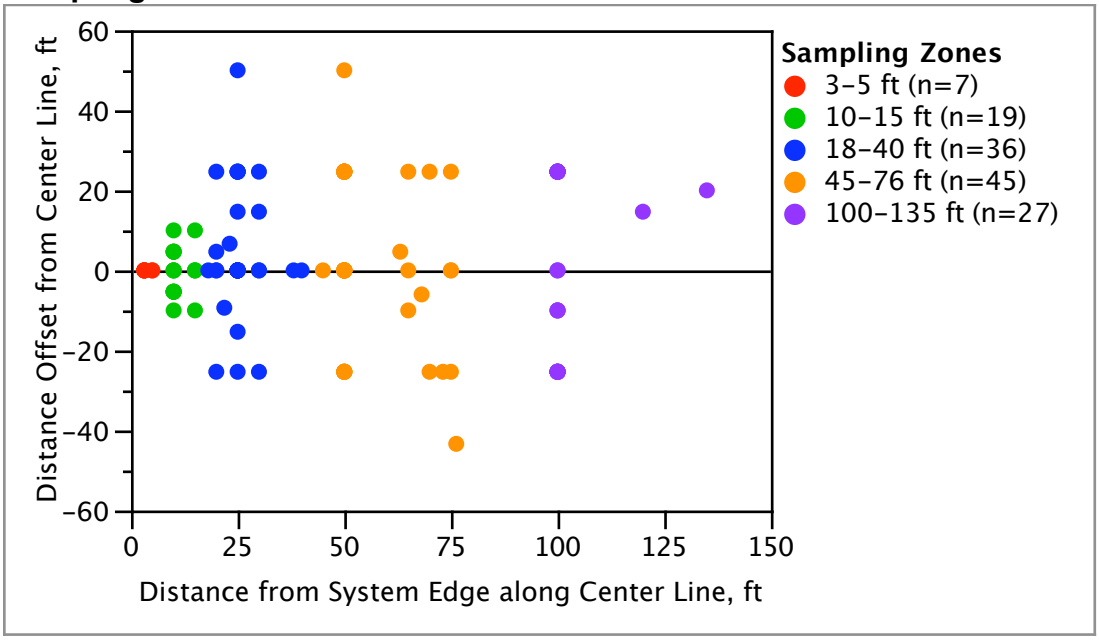
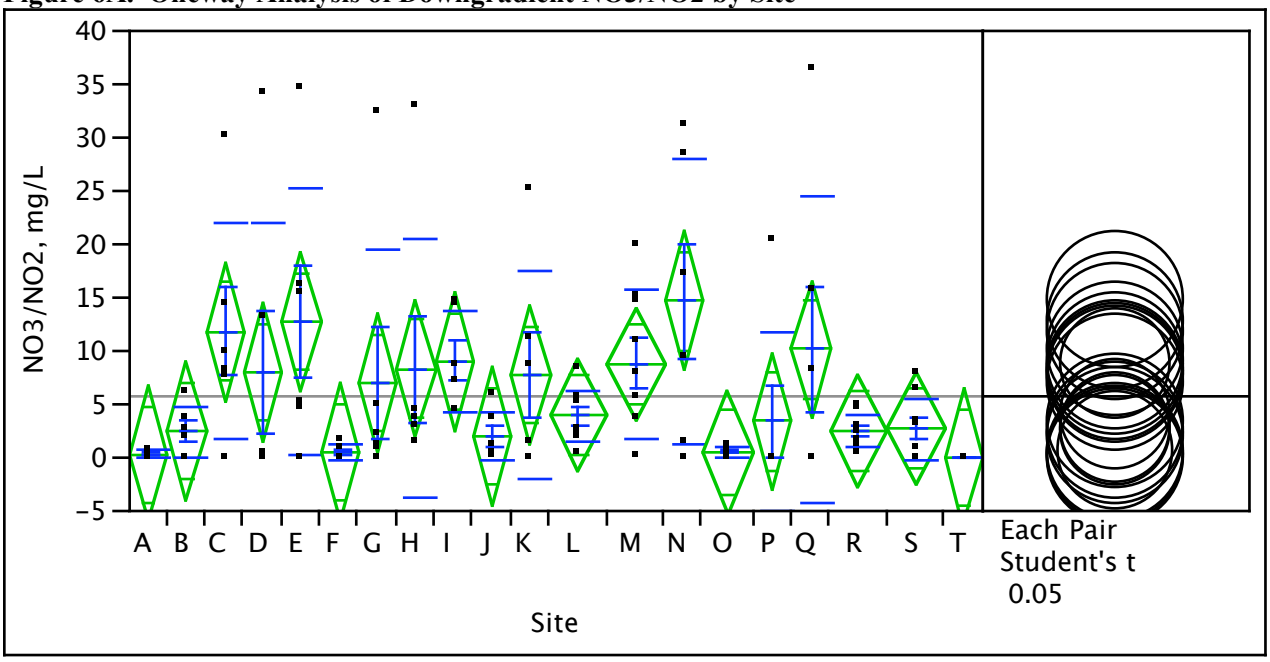


Figure 6A. Oneway Analysis of Downgradient NO3/NO2 by Site



Summary of Fit

Rsquare	0.257634
Adj Rsquare	0.133906
Root Mean Square Error	7.97222
Mean of Response	5.633922
Observations (or Sum Wgts)	134

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	2514.4825	132.341	2.0823	0.0094
Error	114	7245.4165	63.556		
C. Total	133	9759.8990			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	0.3063	0.3509	0.1432	-0.062	0.675
B	6	2.4577	2.3515	0.9600	-0.010	4.925
C	6	11.8210	10.1878	4.1592	1.130	22.512
D	6	8.0122	13.8683	5.6617	-6.542	22.566
E	6	12.7458	12.5772	5.1346	-0.453	25.945
F	6	0.4383	0.6946	0.2836	-0.291	1.167
G	6	6.9983	12.6133	5.1494	-6.238	20.235
H	6	8.3417	12.1830	4.9737	-4.444	21.127
I	6	9.0333	4.6687	1.9060	4.134	13.933
J	6	1.9877	2.3477	0.9584	-0.476	4.451
K	6	7.8143	9.7531	3.9817	-2.421	18.049
L	9	3.9092	2.4540	0.8180	2.023	5.796
M	9	8.8106	6.9479	2.3160	3.470	14.151
N	6	14.6819	13.3291	5.4416	0.694	28.670
O	8	0.5423	0.4666	0.1650	0.152	0.932
P	6	3.4188	8.3190	3.3962	-5.311	12.149
Q	6	10.1369	14.4159	5.8853	-4.992	25.265
R	9	2.5262	1.5388	0.5129	1.343	3.709
S	9	2.6768	2.8541	0.9514	0.483	4.871
T	6	0.0229	0.0164	0.0067	0.00569	0.040

Means Comparisons

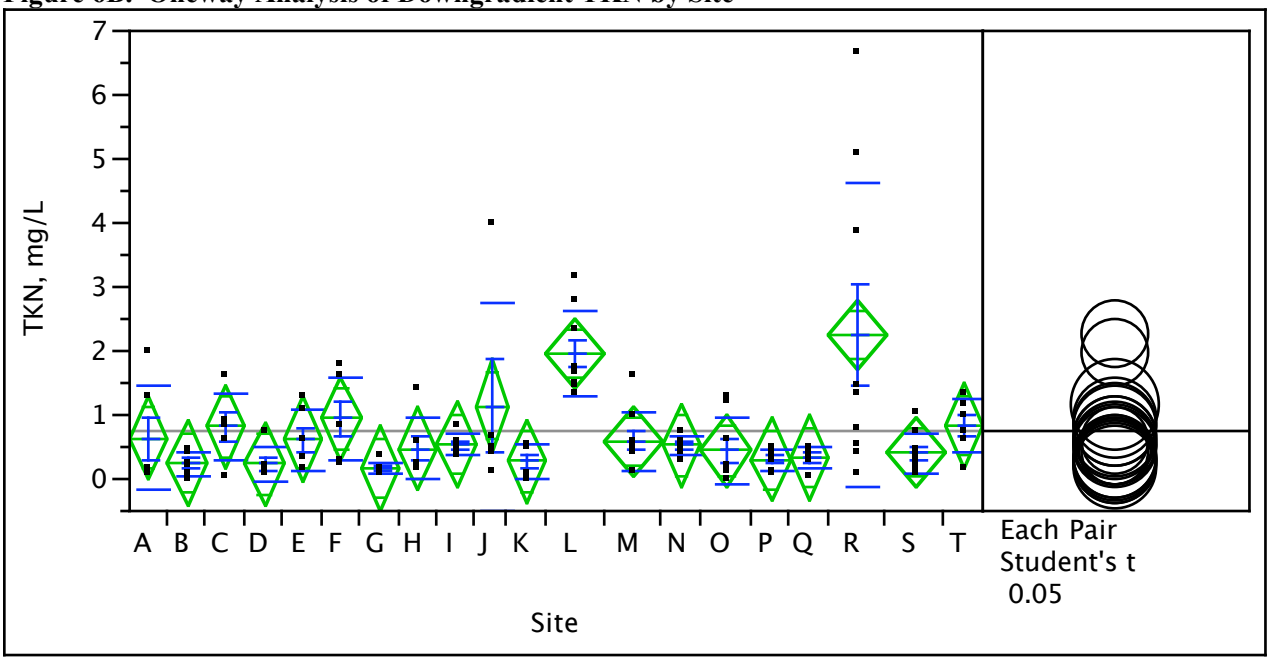
Comparisons for each pair using Student's t

t	Alpha
1.98099	0.05

Level					Mean
N	A				14.681917
E	A				12.745780
C	A	B			11.821000
Q	A	B	C		10.136857
I	A	B	C	D	9.033333
M	A	B	C		8.810556
H	A	B	C	D	8.341667
D	A	B	C	D	8.012177
K	A	B	C	D	7.814250
G	A	B	C	D	6.998333
L		B	C	D	3.909222
P		B	C	D	3.418833
S			C	D	2.676778
R			C	D	2.526222
B			C	D	2.457675
J			C	D	1.987667
O				D	0.542312
F				D	0.438333
A				D	0.306300
T				D	0.022883

Levels not connected by same letter are significantly different

Figure 6B. Oneway Analysis of Downgradient TKN by Site



Missing Rows = 1

Summary of Fit

Rsquare	0.384535
Adj Rsquare	0.28105
Root Mean Square Error	0.812604
Mean of Response	0.735353
Observations (or Sum Wgts)	133

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	46.61959	2.45366	3.7158	<.0001
Error	113	74.61672	0.66032		
C. Total	132	121.23631			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	0.64033	0.82215	0.33564	-0.222	1.5031
B	6	0.24217	0.18235	0.07444	0.051	0.4335
C	6	0.81383	0.51648	0.21085	0.272	1.3558
D	6	0.23083	0.26053	0.10636	-0.043	0.5042
E	6	0.61417	0.47801	0.19515	0.113	1.1158
F	6	0.93833	0.64964	0.26521	0.257	1.6201
G	6	0.16983	0.09777	0.03992	0.067	0.2724
H	6	0.47517	0.48483	0.19793	-0.034	0.9840
I	6	0.53383	0.15999	0.06532	0.366	0.7017
J	5	1.13900	1.62234	0.72553	-0.875	3.1534
K	6	0.27633	0.27000	0.11023	-0.007	0.5597
L	9	1.96333	0.65182	0.21727	1.462	2.4644
M	9	0.59633	0.46194	0.15398	0.241	0.9514
N	6	0.52333	0.16063	0.06558	0.355	0.6919
O	8	0.44963	0.52305	0.18493	0.012	0.8869
P	6	0.30533	0.17227	0.07033	0.125	0.4861
Q	6	0.33267	0.16859	0.06883	0.156	0.5096
R	9	2.25356	2.36580	0.78860	0.435	4.0721
S	9	0.40111	0.31473	0.10491	0.159	0.6430
T	6	0.83400	0.42246	0.17247	0.391	1.2773

Means Comparisons

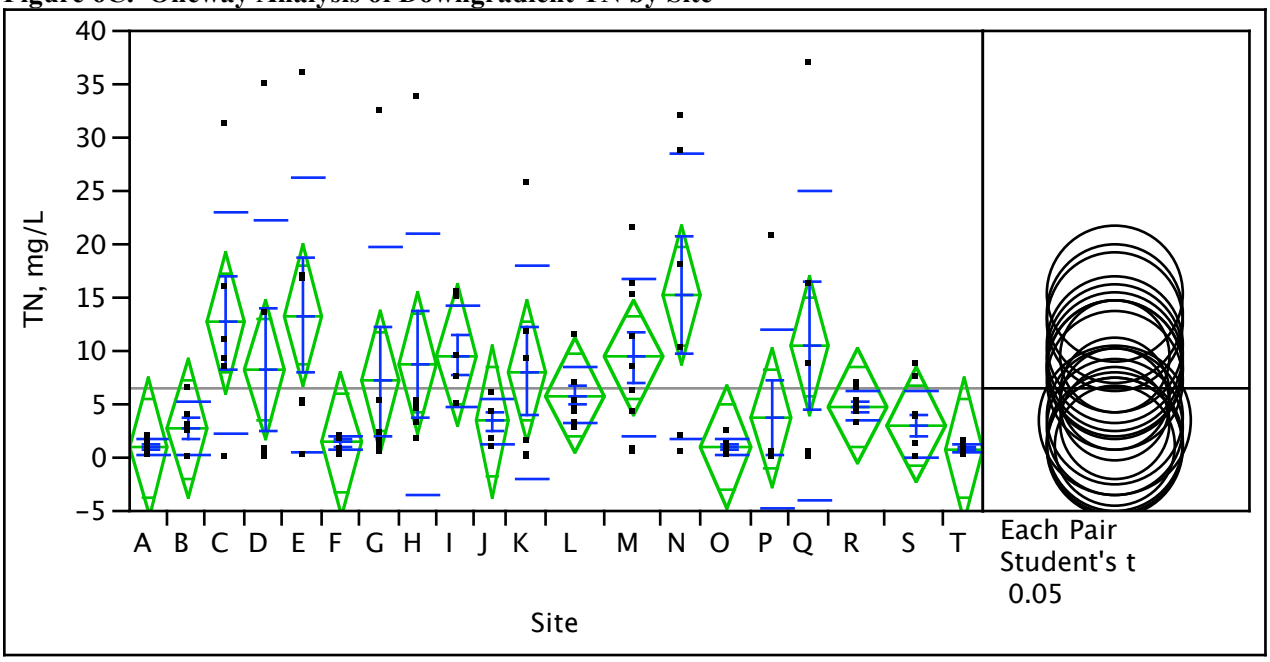
Comparisons for each pair using Student's t

t	Alpha
1.98118	0.05

Level				Mean
R	A			2.2535556
L	A	B		1.9633333
J		B	C	1.1390000
F			C	0.9383333
T			C	0.8340000
C			C	0.8138333
A			C	0.6403333
E			C	0.6141667
M			C	0.5963333
I			C	0.5338333
N			C	0.5233333
H			C	0.4751667
O			C	0.4496250
S			C	0.4011111
Q			C	0.3326667
P			C	0.3053333
K			C	0.2763333
B			C	0.2421667
D			C	0.2308333
G			C	0.1698333

Levels not connected by same letter are significantly different

Figure 6C. Oneway Analysis of Downgradient TN by Site



Missing Rows = 1

Summary of Fit

Rsquare	0.239656
Adj Rsquare	0.111811
Root Mean Square Error	8.121937
Mean of Response	6.407504
Observations (or Sum Wgts)	133

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	2349.5073	123.658	1.8746	0.0228
Error	113	7454.1414	65.966		
C. Total	132	9803.6487			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	0.9466	0.7583	0.3096	0.151	1.742
B	6	2.6990	2.4865	1.0151	0.090	5.308
C	6	12.6348	10.4487	4.2657	1.670	23.600
D	6	8.2430	14.1024	5.7573	-6.557	23.043
E	6	13.3599	12.9464	5.2853	-0.226	26.946
F	6	1.3767	0.6615	0.2700	0.683	2.071
G	6	7.1682	12.5814	5.1363	-6.035	20.372
H	6	8.8168	12.2448	4.9989	-4.033	21.667
I	6	9.5672	4.7143	1.9246	4.620	14.515
J	5	3.4288	2.0804	0.9304	0.846	6.012
K	6	8.0889	9.9680	4.0694	-2.372	18.550
L	9	5.8726	2.6857	0.8952	3.808	7.937
M	9	9.4069	7.2975	2.4325	3.798	15.016
N	6	15.2050	13.3355	5.4442	1.210	29.200
O	8	0.9902	0.7033	0.2486	0.402	1.578
P	6	3.7242	8.3885	3.4246	-5.079	12.527
Q	6	10.4695	14.4883	5.9148	-4.735	25.674
R	9	4.7798	1.3974	0.4658	3.706	5.854
S	9	3.0760	3.1470	1.0490	0.657	5.495
T	6	0.8526	0.4160	0.1698	0.416	1.289

Means Comparisons

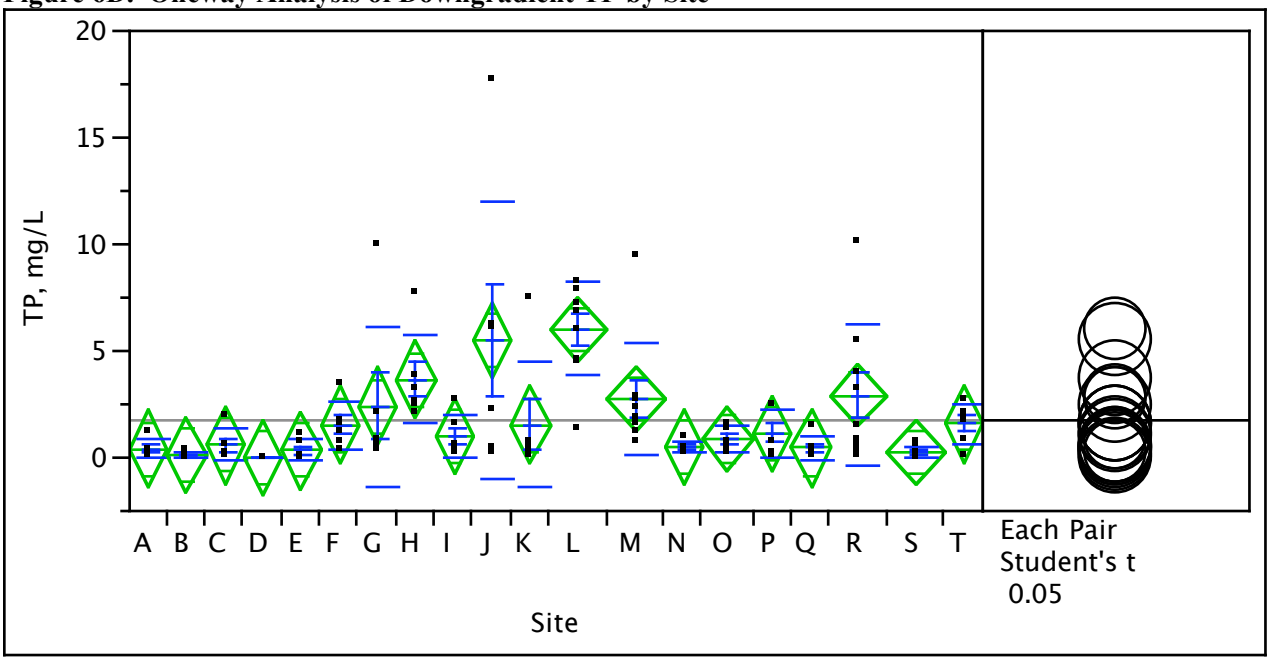
Comparisons for each pair using Student's t

t	Alpha
1.98118	0.05

Level							Mean
N	A						15.205000
E	A	B					13.359947
C	A	B	C				12.634833
Q	A	B	C	D			10.469523
I	A	B	C	D	E	F	9.567167
M	A	B	C	D		F	9.406889
H	A	B	C	D	E	F	8.816833
D	A	B	C	D	E	F	8.243010
K	A	B	C	D	E	F	8.088917
G	A	B	C	D	E	F	7.168167
L		B	C	D	E	F	5.872556
R			C	D	E	F	4.779778
P			C	D	E	F	3.724167
J			C	D	E	F	3.428800
S				D	E	F	3.076000
B				D	E	F	2.699008
F				D	E	F	1.376667
O					E		0.990250
A					E	F	0.946633
T					E		0.852633

Levels not connected by same letter are significantly different

Figure 6D. Oneway Analysis of Downgradient TP by Site



Summary of Fit

Rsquare	0.424035
Adj Rsquare	0.32804
Root Mean Square Error	2.213193
Mean of Response	1.787735
Observations (or Sum Wgts)	134

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	411.10088	21.6369	4.4173	<.0001
Error	114	558.39742	4.8982		
C. Total	133	969.49830			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	0.39883	0.41726	0.1703	-0.039	0.837
B	6	0.11867	0.15625	0.0638	-0.045	0.283
C	6	0.59167	0.74149	0.3027	-0.186	1.370
D	6	0.01975	0.01251	0.0051	0.00662	0.033
E	6	0.35000	0.50208	0.2050	-0.177	0.877
F	6	1.54600	1.10951	0.4530	0.382	2.710
G	6	2.40417	3.78159	1.5438	-1.564	6.373
H	6	3.66833	2.06163	0.8417	1.505	5.832
I	6	1.02117	0.98280	0.4012	-0.010	2.053
J	6	5.50783	6.52824	2.6651	-1.343	12.359
K	6	1.54300	2.93107	1.1966	-1.533	4.619
L	9	6.01000	2.18980	0.7299	4.327	7.693
M	9	2.76567	2.62756	0.8759	0.746	4.785
N	6	0.49883	0.23651	0.0966	0.251	0.747
O	8	0.87638	0.58351	0.2063	0.389	1.364
P	6	1.13933	1.07708	0.4397	0.00901	2.270
Q	6	0.45283	0.53122	0.2169	-0.105	1.010
R	9	2.92356	3.26656	1.0889	0.413	5.434
S	9	0.23956	0.25827	0.0861	0.041	0.438
T	6	1.58900	0.92140	0.3762	0.622	2.556

Means Comparisons

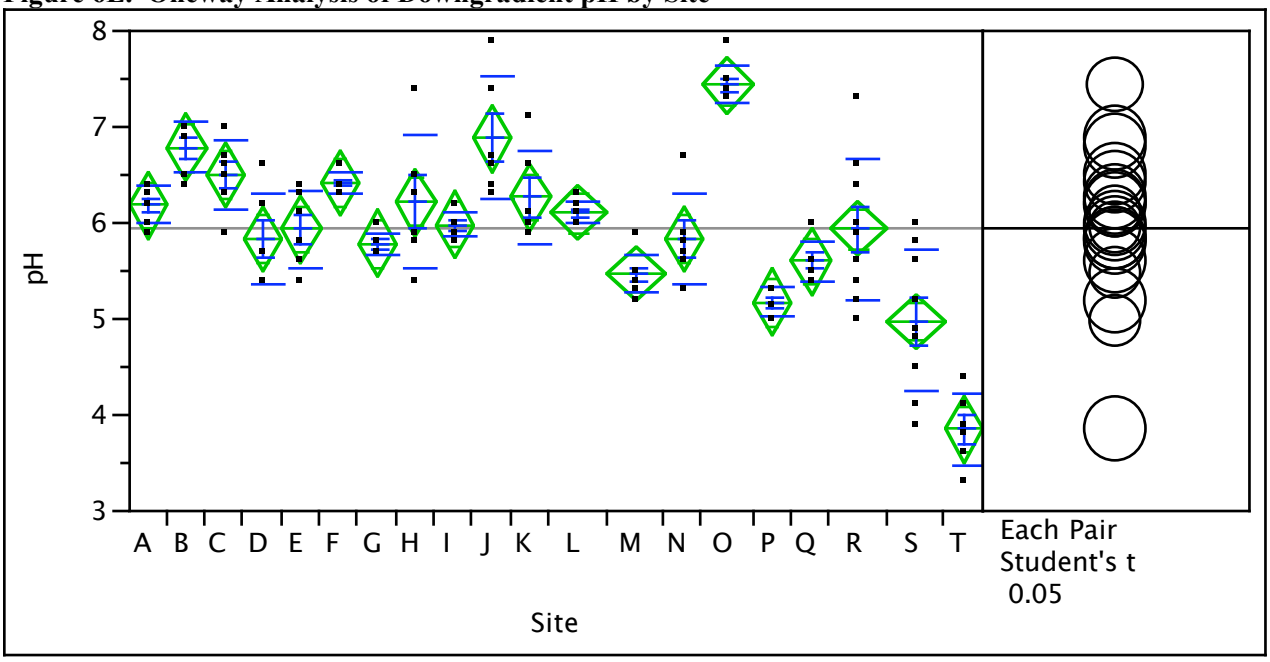
Comparisons for each pair using Student's t

t	Alpha
1.98099	0.05

Level							Mean
L	A						6.0100000
J	A	B					5.5078333
H		B	C				3.6683333
R			C	D			2.9235556
M			C	D	E		2.7656667
G			C	D	E	F	2.4041667
T			C	D	E	F	1.5890000
F			C	D	E	F	1.5460000
K			C	D	E	F	1.5430000
P			C	D	E	F	1.1393333
I				D	E	F	1.0211667
O				D	E	F	0.8763750
C					E	F	0.5916667
N					E	F	0.4988333
Q						F	0.4528333
A						F	0.3988333
E						F	0.3500000
S						F	0.2395556
B						F	0.1186667
D						F	0.0197500

Levels not connected by same letter are significantly different

Figure 6E. Oneway Analysis of Downgradient pH by Site



Summary of Fit

Rsquare	0.781948
Adj Rsquare	0.745606
Root Mean Square Error	0.424172
Mean of Response	5.949478
Observations (or Sum Wgts)	134

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	73.553808	3.87125	21.5163	<.0001
Error	114	20.511056	0.17992		
C. Total	133	94.064863			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	6.18333	0.194079	0.07923	5.9797	6.3870
B	6	6.78333	0.263944	0.10775	6.5063	7.0603
C	6	6.50000	0.374166	0.15275	6.1073	6.8927
D	6	5.83333	0.476095	0.19437	5.3337	6.3330
E	6	5.93333	0.398330	0.16262	5.5153	6.3514
F	6	6.41667	0.098319	0.04014	6.3135	6.5198
G	6	5.78333	0.116905	0.04773	5.6606	5.9060
H	6	6.21667	0.696898	0.28451	5.4853	6.9480
I	6	5.98333	0.132916	0.05426	5.8438	6.1228
J	6	6.88333	0.630608	0.25744	6.2216	7.5451
K	6	6.26667	0.484424	0.19777	5.7583	6.7750
L	9	6.10000	0.111803	0.03727	6.0141	6.1859
M	9	5.46667	0.193649	0.06455	5.3178	5.6155
N	6	5.83333	0.471876	0.19264	5.3381	6.3285
O	8	7.43750	0.199553	0.07055	7.2707	7.6043
P	6	5.17167	0.148380	0.06058	5.0160	5.3274
Q	6	5.60000	0.209762	0.08563	5.3799	5.8201
R	9	5.93333	0.736546	0.24552	5.3672	6.4995
S	9	4.97778	0.737865	0.24595	4.4106	5.5450
T	6	3.85000	0.383406	0.15652	3.4476	4.2524

Means Comparisons

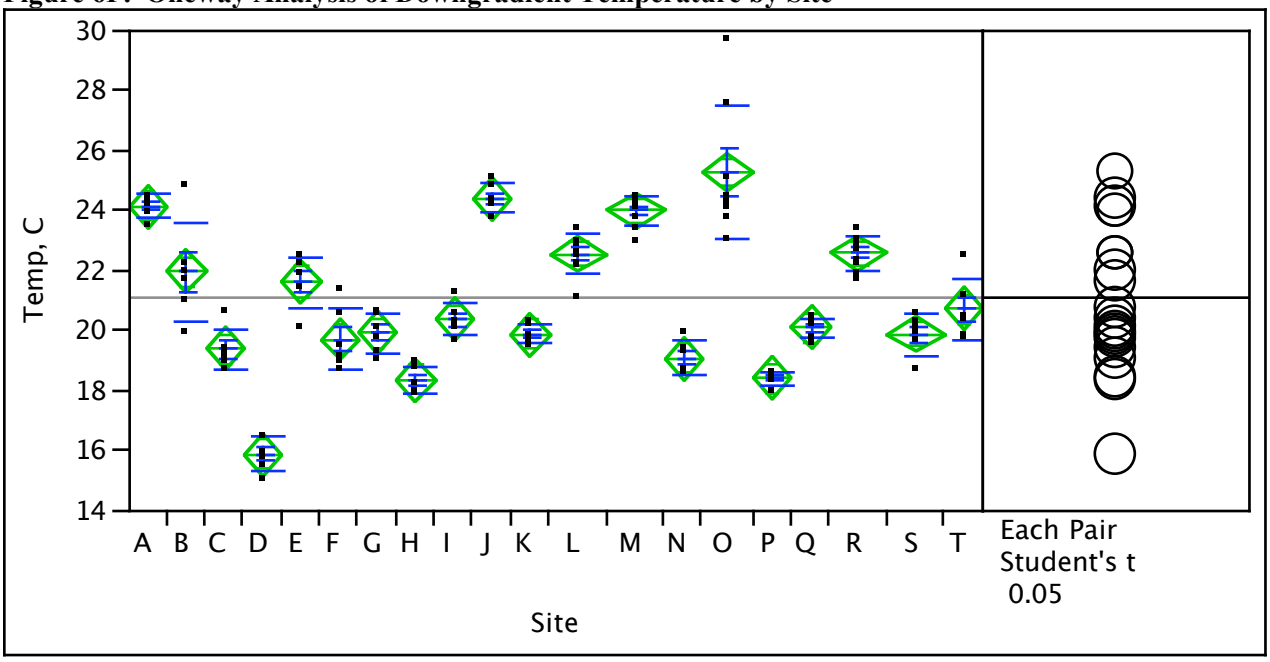
Comparisons for each pair using Student's t

t	Alpha
1.98099	0.05

Level										Mean
O	A									7.4375000
J		B								6.8833333
B		B								6.7833333
C		B	C							6.5000000
F		B	C	D						6.4166667
K			C	D	E					6.2666667
H			C	D	E					6.2166667
A			C	D	E					6.1833333
L			C	D	E					6.1000000
I				D	E	F				5.9833333
R					E	F				5.9333333
E				D	E	F				5.9333333
N					E	F	G			5.8333333
D					E	F	G			5.8333333
G					E	F	G			5.7833333
Q						F	G	H		5.6000000
M							G	H		5.4666667
P								H	I	5.1716667
S									I	4.9777778
T										J 3.8500000

Levels not connected by same letter are significantly different

Figure 6F. Oneway Analysis of Downgradient Temperature by Site



Summary of Fit

Rsquare	0.892499
Adj Rsquare	0.874582
Root Mean Square Error	0.876235
Mean of Response	21.10522
Observations (or Sum Wgts)	134

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	726.67857	38.2462	49.8136	<.0001
Error	114	87.52778	0.7678		
C. Total	133	814.20634			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	24.1667	0.37771	0.15420	23.770	24.563
B	6	21.9667	1.61328	0.65862	20.274	23.660
C	6	19.3833	0.69113	0.28215	18.658	20.109
D	6	15.9000	0.55498	0.22657	15.318	16.482
E	6	21.6333	0.85479	0.34897	20.736	22.530
F	6	19.7333	1.04626	0.42714	18.635	20.831
G	6	19.9333	0.65929	0.26916	19.241	20.625
H	6	18.3833	0.43551	0.17780	17.926	18.840
I	6	20.3667	0.54283	0.22161	19.797	20.936
J	6	24.4333	0.45898	0.18738	23.952	24.915
K	6	19.8833	0.31885	0.13017	19.549	20.218
L	9	22.5444	0.65786	0.21929	22.039	23.050
M	9	24.0000	0.50498	0.16833	23.612	24.388
N	6	19.1000	0.56569	0.23094	18.506	19.694
O	8	25.2750	2.23143	0.78893	23.409	27.141
P	6	18.4167	0.21370	0.08724	18.192	18.641
Q	6	20.1000	0.33466	0.13663	19.749	20.451
R	9	22.6000	0.56789	0.18930	22.163	23.037
S	9	19.8778	0.72419	0.24140	19.321	20.434
T	6	20.7167	1.00681	0.41103	19.660	21.773

Means Comparisons

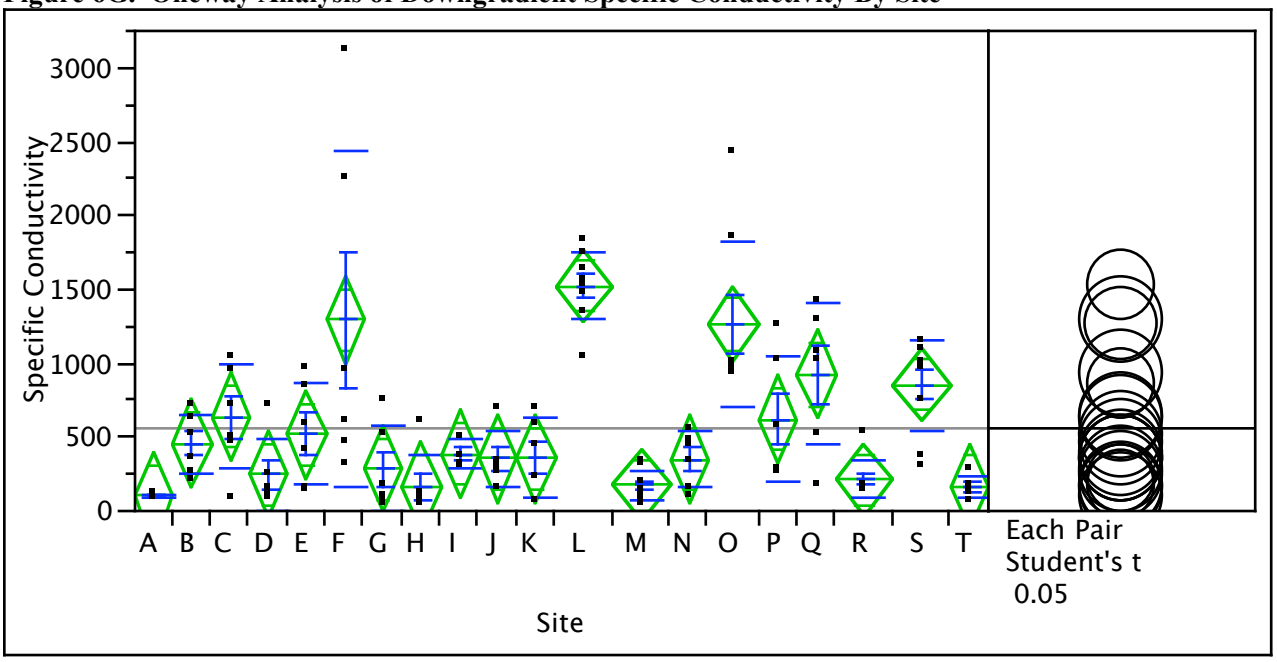
Comparisons for each pair using Student's t

t	Alpha
1.98099	0.05

Level											Mean
O	A										25.275000
J	A	B									24.433333
A		B									24.166667
M		B									24.000000
R			C								22.600000
L			C	D							22.544444
B			C	D							21.966667
E				D	E						21.633333
T					E	F					20.716667
I						F	G				20.366667
Q						F	G	H			20.100000
G						F	G	H			19.933333
K						F	G	H			19.883333
S						F	G	H			19.877778
F						F	G	H			19.733333
C							G	H	I		19.383333
N								H	I		19.100000
P									I		18.416667
H									I		18.383333
D										J	15.900000

Levels not connected by same letter are significantly different

Figure 6G. Oneway Analysis of Downgradient Specific Conductivity By Site



Summary of Fit

Rsquare	0.618362
Adj Rsquare	0.554755
Root Mean Square Error	366.4788
Mean of Response	567.9037
Observations (or Sum Wgts)	134

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	19	24808094	1305689	9.7217	<.0001
Error	114	15310965	134307		
C. Total	133	40119059			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	99.57	15.47	6.31	83	115.8
B	6	453.50	201.46	82.24	242	664.9
C	6	634.67	353.10	144.15	264	1005.2
D	6	244.33	244.04	99.63	-12	500.4
E	6	521.53	343.94	140.41	161	882.5
F	6	1293.33	1138.98	464.99	98	2488.6
G	6	284.82	289.71	118.27	-19	588.8
H	6	167.70	218.00	89.00	-61	396.5
I	6	386.67	95.75	39.09	286	487.1
J	6	353.17	182.07	74.33	162	544.2
K	6	356.22	266.87	108.95	76	636.3
L	9	1524.33	233.00	77.67	1345	1703.4
M	9	174.03	99.48	33.16	98	250.5
N	6	349.47	184.04	75.13	156	542.6
O	8	1263.12	565.87	200.07	790	1736.2
P	6	618.67	427.43	174.50	170	1067.2
Q	6	922.57	476.99	194.73	422	1423.1
R	9	215.27	125.67	41.89	119	311.9
S	9	854.33	307.37	102.46	618	1090.6
T	6	160.87	71.09	29.02	86	235.5

Means Comparisons

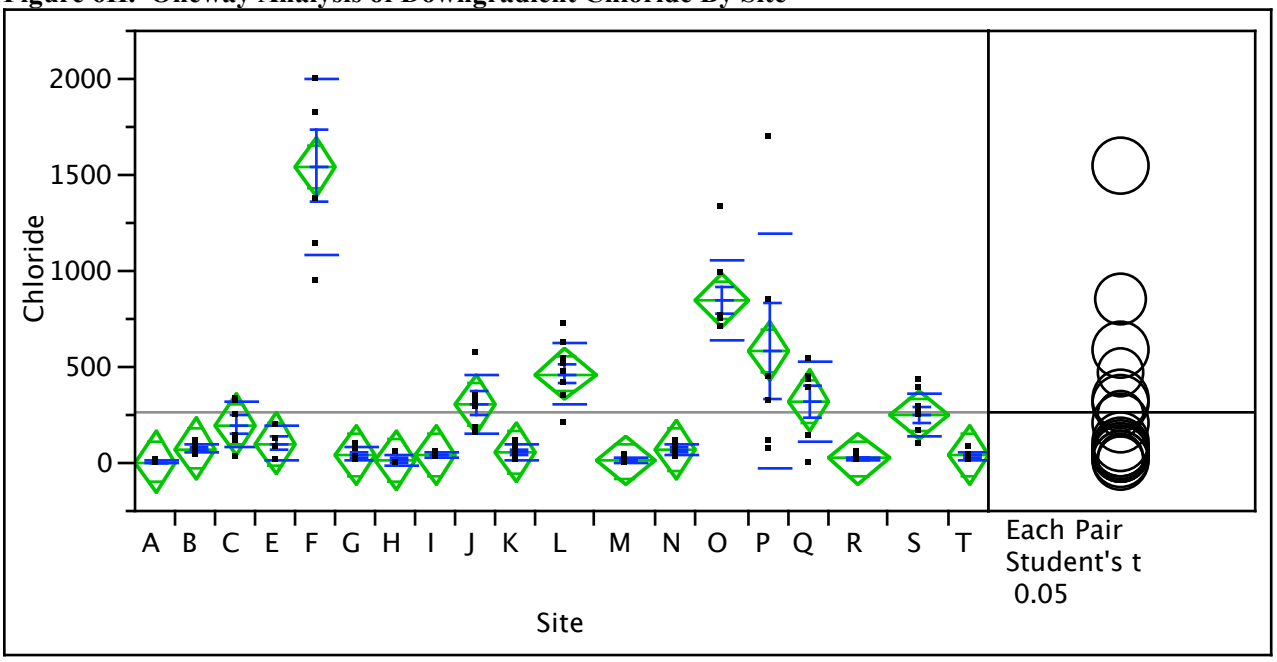
Comparisons for each pair using Student's t

t	Alpha
1.98099	0.05

Level							Mean
L	A						1524.3333
F	A	B					1293.3333
O	A	B					1263.1250
Q		B	C				922.5667
S			C				854.3333
C			C	D			634.6667
P			C	D			618.6667
E			C	D	E		521.5333
B				D	E	F	453.5000
I				D	E	F	386.6667
K				D	E	F	356.2167
J				D	E	F	353.1667
N				D	E	F	349.4667
G				D	E	F	284.8167
D				D	E	F	244.3333
R					E	F	215.2667
M					E	F	174.0333
H					E	F	167.7000
T					E	F	160.8667
A						F	99.5667

Levels not connected by same letter are significantly different

Figure 6H. Oneway Analysis of Downgradient Chloride By Site



Missing Rows = 6

Summary of Fit

Rsquare	0.810809
Adj Rsquare	0.779567
Root Mean Square Error	192.0713
Mean of Response	265.0989
Observations (or Sum Wgts)	128

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site	18	17233370	957409	25.9521	<.0001
Error	109	4021160	36891		
C. Total	127	21254530			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	6	6.18	1.701	0.69	4.39816	8.0
B	6	75.95	26.780	10.93	48	104.1
C	6	200.47	123.518	50.43	71	330.1
E	6	102.77	85.012	34.71	14	192.0
F	6	1544.17	455.795	186.08	1066	2022.5
G	6	43.05	33.579	13.71	7.81091	78.3
H	6	10.89	24.696	10.08	-15	36.8
I	6	42.38	13.401	5.47	28	56.4
J	6	309.50	152.719	62.35	149	469.8
K	6	53.52	38.734	15.81	13	94.2
L	9	464.44	155.256	51.75	345	583.8
M	9	11.37	13.047	4.35	1.33768	21.4
N	6	70.53	32.098	13.10	37	104.2
O	8	848.00	213.264	75.40	670	1026.3
P	6	583.02	614.379	250.82	-62	1227.8
Q	6	323.88	206.995	84.51	107	541.1
R	9	21.53	12.014	4.00	12	30.8
S	9	249.78	116.935	38.98	160	339.7
T	6	37.78	24.048	9.82	13	63.0

Means Comparisons

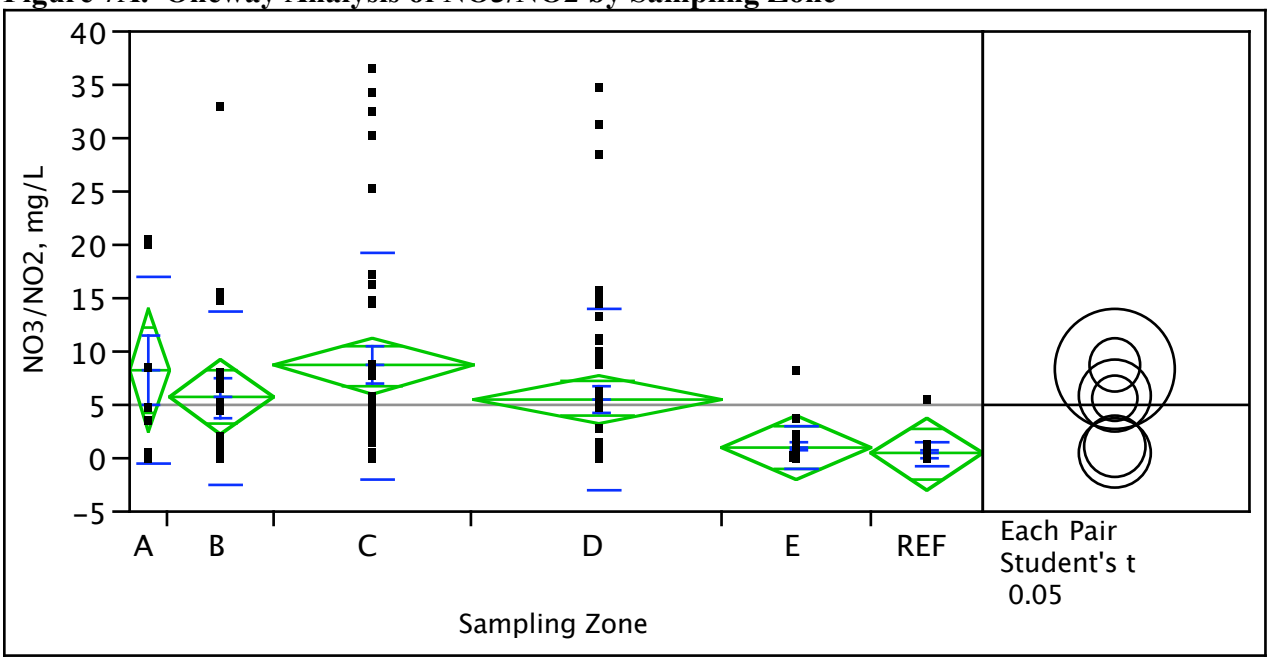
Comparisons for each pair using Student's t

t	Alpha
1.98197	0.05

Level								Mean
F	A							1544.1667
O		B						848.0000
P			C					583.0167
L			C	D				464.4444
Q				D	E			323.8833
J				D	E	F		309.5000
S					E	F	G	249.7778
C					E	F	G	H 200.4667
E						F	G	H 102.7667
B							G	H 75.9500
N							G	H 70.5333
K							G	H 53.5167
G								H 43.0500
I								H 42.3833
T								H 37.7833
R								H 21.5333
M								H 11.3667
H								H 10.8933
A								H 6.1833

Levels not connected by same letter are significantly different

Figure 7A. Oneway Analysis of NO3/NO2 by Sampling Zone



Summary of Fit

Rsquare	0.139777
Adj Rsquare	0.110715
Root Mean Square Error	7.725774
Mean of Response	4.951098
Observations (or Sum Wgts)	154

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	1435.387	287.077	4.8097	0.0004
Error	148	8833.762	59.688		
C. Total	153	10269.149			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	8.22636	8.6499	3.2693	0.227	16.226
B	19	5.65616	8.1089	1.8603	1.748	9.564
C	36	8.66507	10.5452	1.7575	5.097	12.233
D	45	5.56836	8.5107	1.2687	3.011	8.125
E	27	1.01391	1.9020	0.3660	0.262	1.766
REF	20	0.37618	1.2177	0.2723	-0.194	0.946

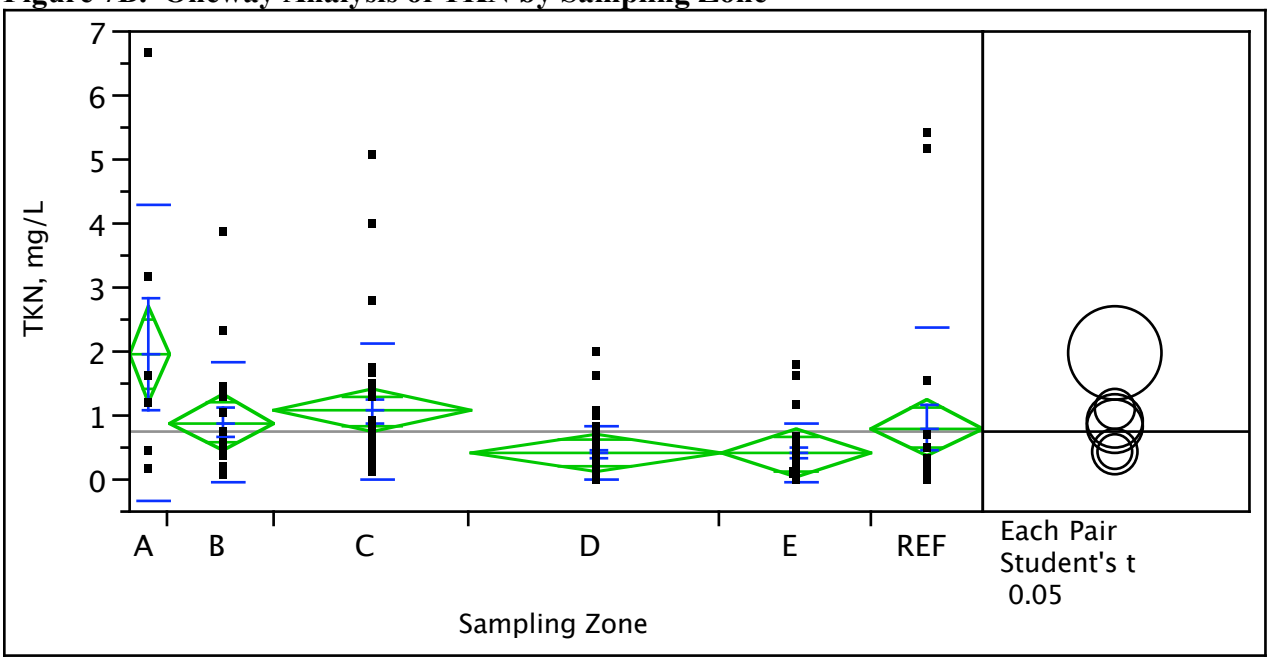
Comparisons for each pair using Student's t

t	Alpha
1.97612	0.05

Level		Mean
C	A	8.6650667
A	A	8.2263571
B	A	5.6561579
D	A	5.5683567
E	B	1.0139104
REF	B	0.3761765

Levels not connected by same letter are significantly different

Figure 7B. Oneway Analysis of TKN by Sampling Zone



Missing Rows = 1

Summary of Fit

Rsquare	0.132912
Adj Rsquare	0.103419
Root Mean Square Error	0.997215
Mean of Response	0.743569
Observations (or Sum Wgts)	153

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	22.40768	4.48154	4.5066	0.0008
Error	147	146.18236	0.99444		
C. Total	152	168.59004			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	1.95986	2.31116	0.87354	-0.1776	4.0973
B	19	0.89389	0.93185	0.21378	0.4448	1.3430
C	35	1.06800	1.05359	0.17809	0.7061	1.4299
D	45	0.41360	0.43277	0.06451	0.2836	0.5436
E	27	0.41137	0.44876	0.08636	0.2338	0.5889
REF	20	0.79820	1.57756	0.35275	0.0599	1.5365

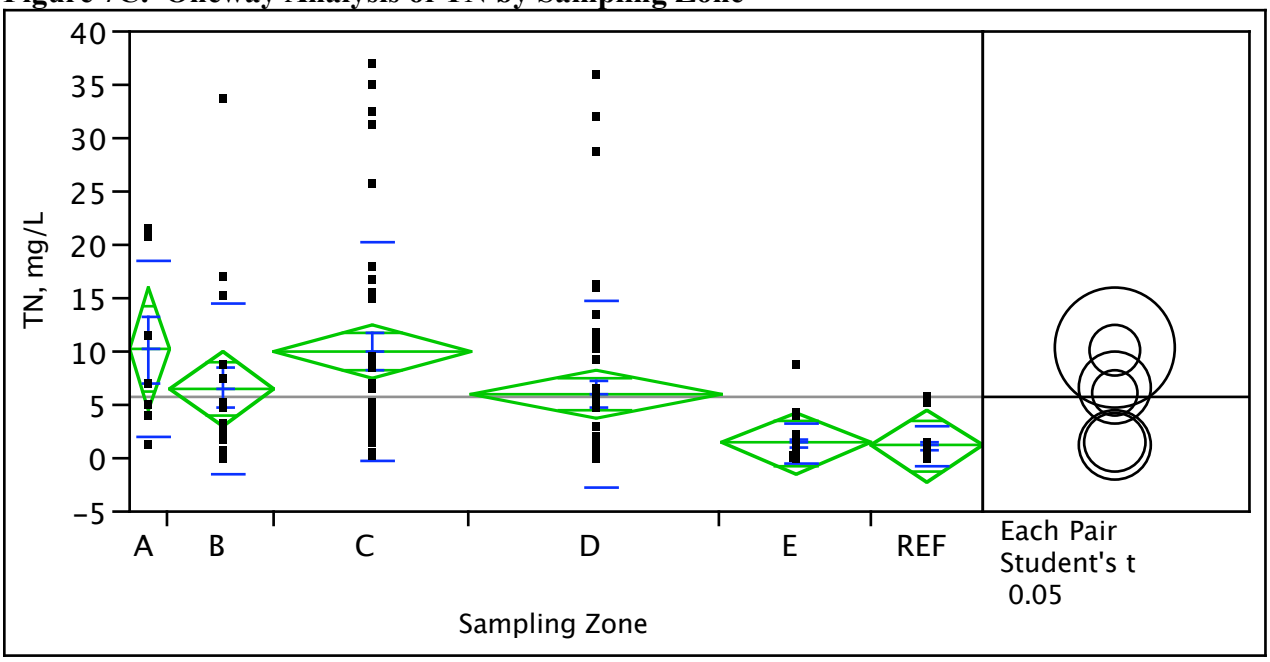
Comparisons for each pair using Student's t

t	Alpha
1.97623	0.05

Level			Mean
A	A		1.9598571
C		B	1.0680000
B		B	C 0.8938947
REF		B	C 0.7982000
D			C 0.4136000
E			C 0.4113704

Levels not connected by same letter are significantly different

Figure 7C. Oneway Analysis of TN by Sampling Zone



Missing Rows = 1

Summary of Fit

Rsquare	0.164192
Adj Rsquare	0.135763
Root Mean Square Error	7.670694
Mean of Response	5.723059
Observations (or Sum Wgts)	153

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	1699.147	339.829	5.7755	<.0001
Error	147	8649.414	58.840		
C. Total	152	10348.561			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	10.1850	8.1928	3.0966	2.6080	17.762
B	19	6.5501	8.0508	1.8470	2.6697	10.430
C	35	9.9670	10.3209	1.7446	6.4217	13.512
D	45	5.9814	8.6504	1.2895	3.3826	8.580
E	27	1.4238	1.9365	0.3727	0.6577	2.190
REF	20	1.1715	1.8956	0.4239	0.2843	2.059

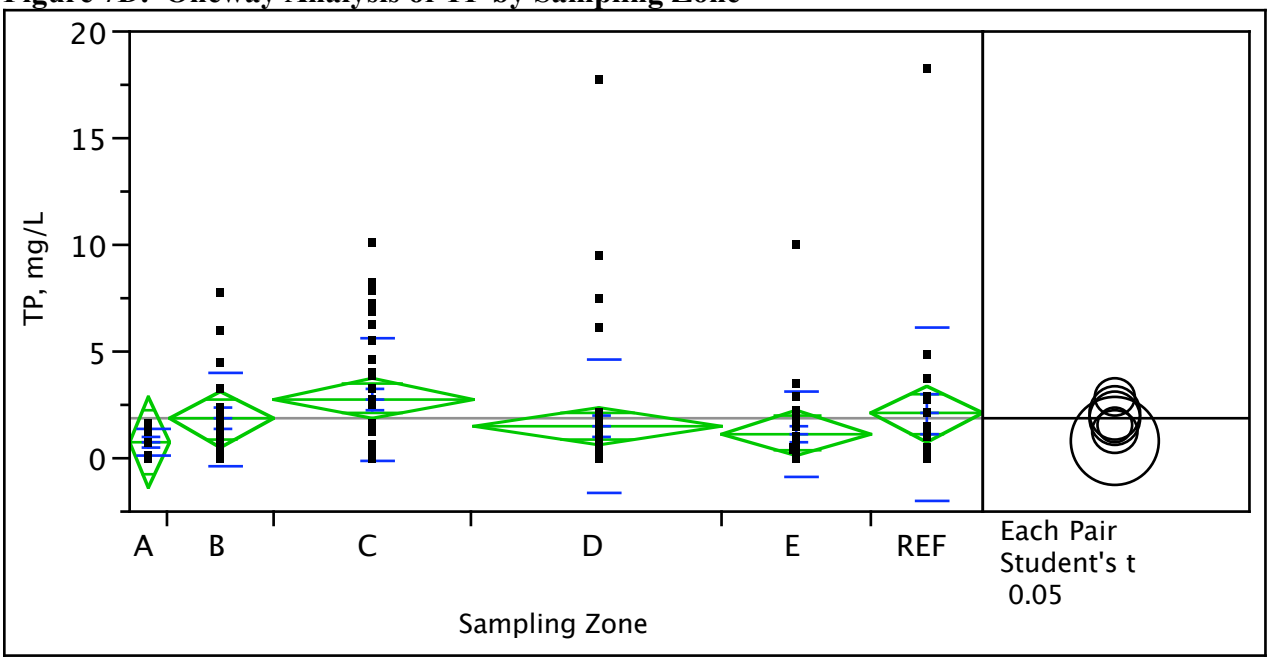
Comparisons for each pair using Student's t

t	Alpha
1.97623	0.05

Level				Mean
A	A	B		10.185000
C	A			9.967011
B	A	B		6.550053
D		B		5.981434
E			C	1.423781
REF			C	1.171501

Levels not connected by same letter are significantly different

Figure 7D. Oneway Analysis of TP by Sampling Zone



Summary of Fit

Rsquare	0.045505
Adj Rsquare	0.013258
Root Mean Square Error	2.875211
Mean of Response	1.823672
Observations (or Sum Wgts)	154

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	58.3292	11.6658	1.4112	0.2235
Error	148	1223.4923	8.2668		
C. Total	153	1281.8215			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	0.76529	0.67046	0.25341	0.1452	1.3854
B	19	1.82847	2.14428	0.49193	0.7950	2.8620
C	36	2.78279	2.88863	0.48144	1.8054	3.7602
D	45	1.50684	3.12753	0.46622	0.5672	2.4465
E	27	1.16556	2.00587	0.38603	0.3721	1.9590
REF	20	2.06445	4.04573	0.90465	0.1710	3.9579

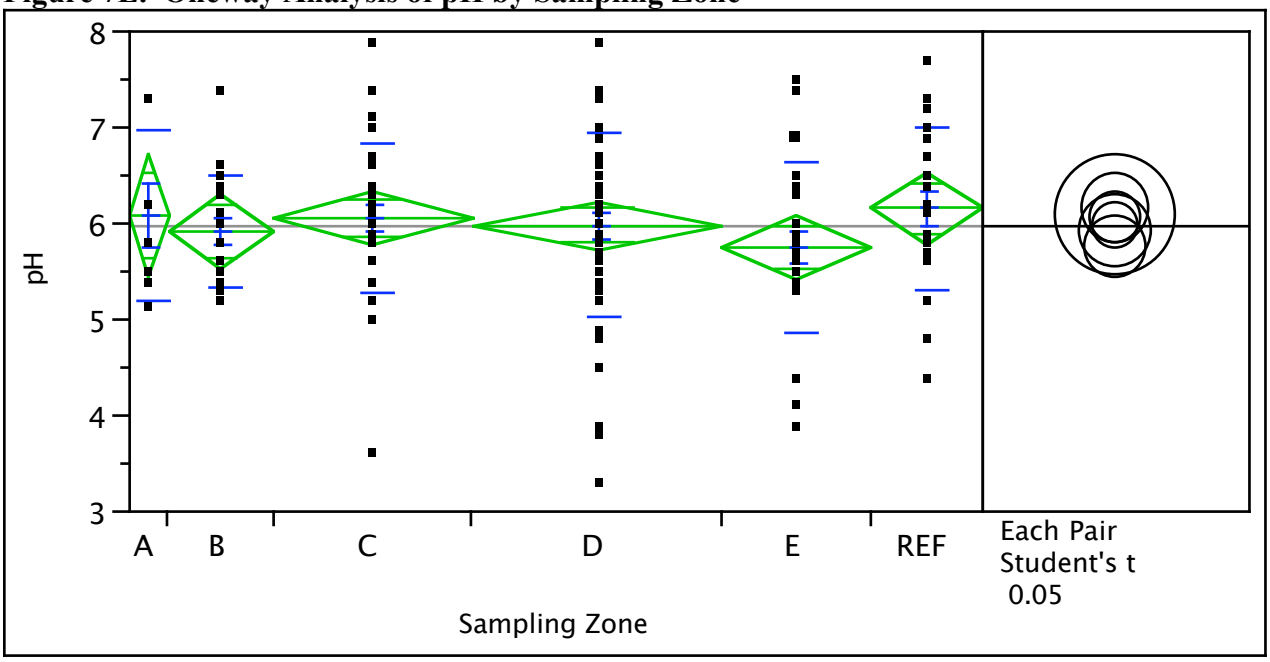
Comparisons for each pair using Student's t

t	Alpha
1.97612	0.05

Level			Mean
C	A		2.7827917
REF	A	B	2.0644500
B	A	B	1.8284737
D		B	1.5068444
E		B	1.1655556
A	A	B	0.7652857

Levels not connected by same letter are significantly different

Figure 7E. Oneway Analysis of pH by Sampling Zone



Summary of Fit

Rsquare	0.02185
Adj Rsquare	-0.0112
Root Mean Square Error	0.846614
Mean of Response	5.976169
Observations (or Sum Wgts)	154

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	2.36957	0.473914	0.6612	0.6535
Error	148	106.07987	0.716756		
C. Total	153	108.44944			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	6.09000	0.891646	0.33701	5.2654	6.9146
B	19	5.91579	0.580482	0.13317	5.6360	6.1956
C	36	6.05278	0.771820	0.12864	5.7916	6.3139
D	45	5.97778	0.955817	0.14248	5.6906	6.2649
E	27	5.75185	0.888980	0.17108	5.4002	6.1035
REF	20	6.15500	0.847582	0.18953	5.7583	6.5517

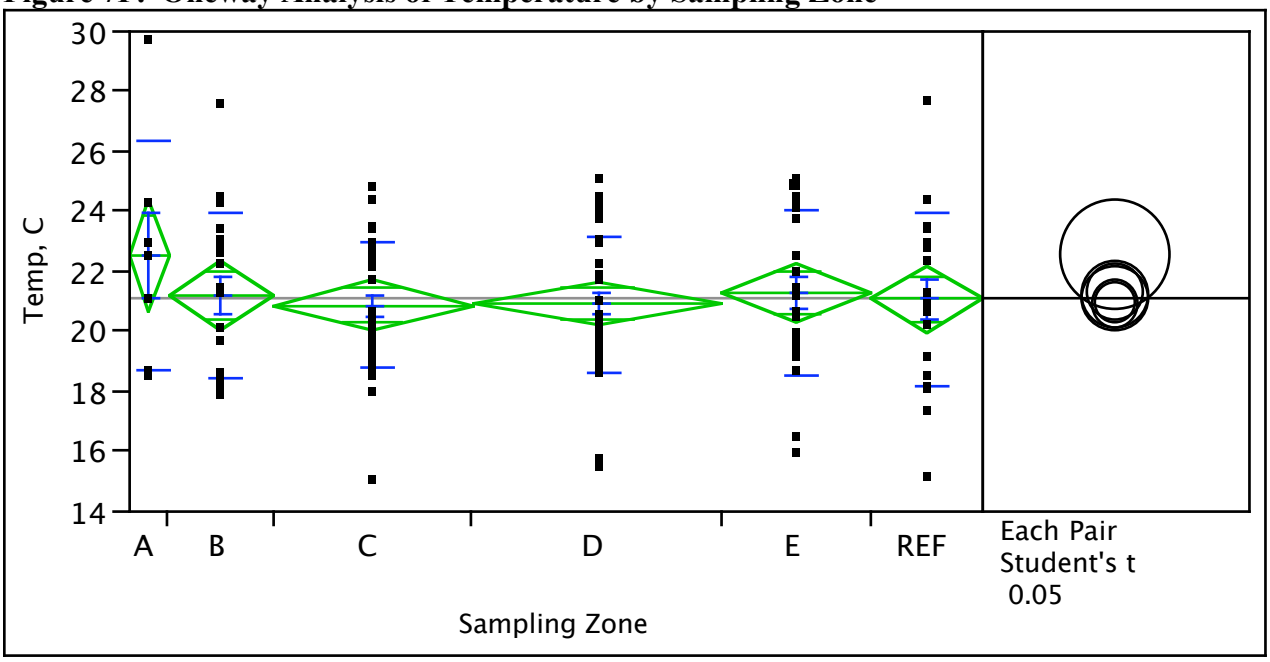
Comparisons for each pair using Student's t

t	Alpha
1.97612	0.05

Level		Mean
REF	A	6.1550000
A	A	6.0900000
C	A	6.0527778
D	A	5.9777778
B	A	5.9157895
E	A	5.7518519

Levels not connected by same letter are significantly different

Figure 7F. Oneway Analysis of Temperature by Sampling Zone



Summary of Fit

Rsquare	0.01974
Adj Rsquare	-0.01338
Root Mean Square Error	2.532957
Mean of Response	21.10065
Observations (or Sum Wgts)	154

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	19.12108	3.82422	0.5961	0.7030
Error	148	949.54886	6.41587		
C. Total	153	968.66994			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	22.5429	3.82355	1.4452	19.007	26.079
B	19	21.2053	2.72121	0.6243	19.894	22.517
C	36	20.8639	2.10104	0.3502	20.153	21.575
D	45	20.9244	2.26918	0.3383	20.243	21.606
E	27	21.2852	2.72477	0.5244	20.207	22.363
REF	20	21.0700	2.85106	0.6375	19.736	22.404

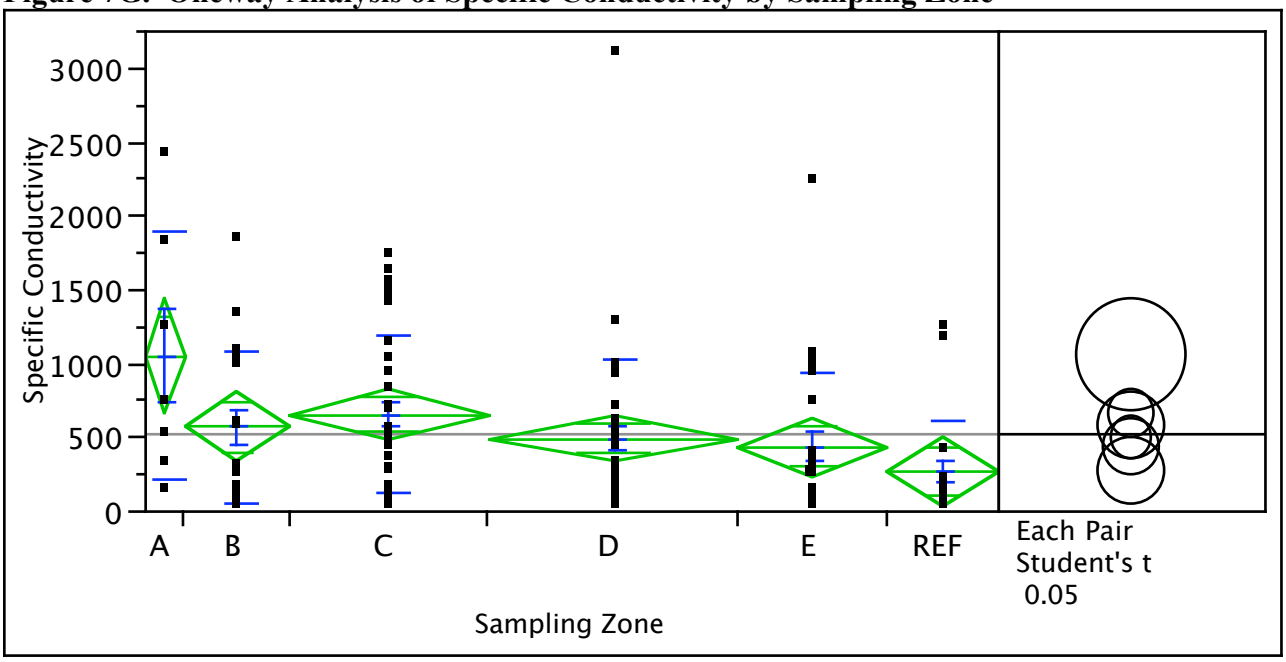
Comparisons for each pair using Student's t

t	Alpha
1.97612	0.05

Level		Mean
A	A	22.542857
E	A	21.285185
B	A	21.205263
REF	A	21.070000
D	A	20.924444
C	A	20.863889

Levels not connected by same letter are significantly different

Figure 7G. Oneway Analysis of Specific Conductivity by Sampling Zone



Summary of Fit

Rsquare	0.093381
Adj Rsquare	0.062752
Root Mean Square Error	518.3258
Mean of Response	529.6468
Observations (or Sum Wgts)	154

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	4095441	819088	3.0488	0.0119
Error	148	39761918	268662		
C. Total	153	43857359			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	1049.40	838.062	316.76	274.32	1824.5
B	19	571.90	512.348	117.54	324.96	818.8
C	36	657.61	530.264	88.38	478.19	837.0
D	45	496.29	525.321	78.31	338.47	654.1
E	27	440.00	504.252	97.04	240.53	639.5
REF	20	273.32	342.450	76.57	113.05	433.6

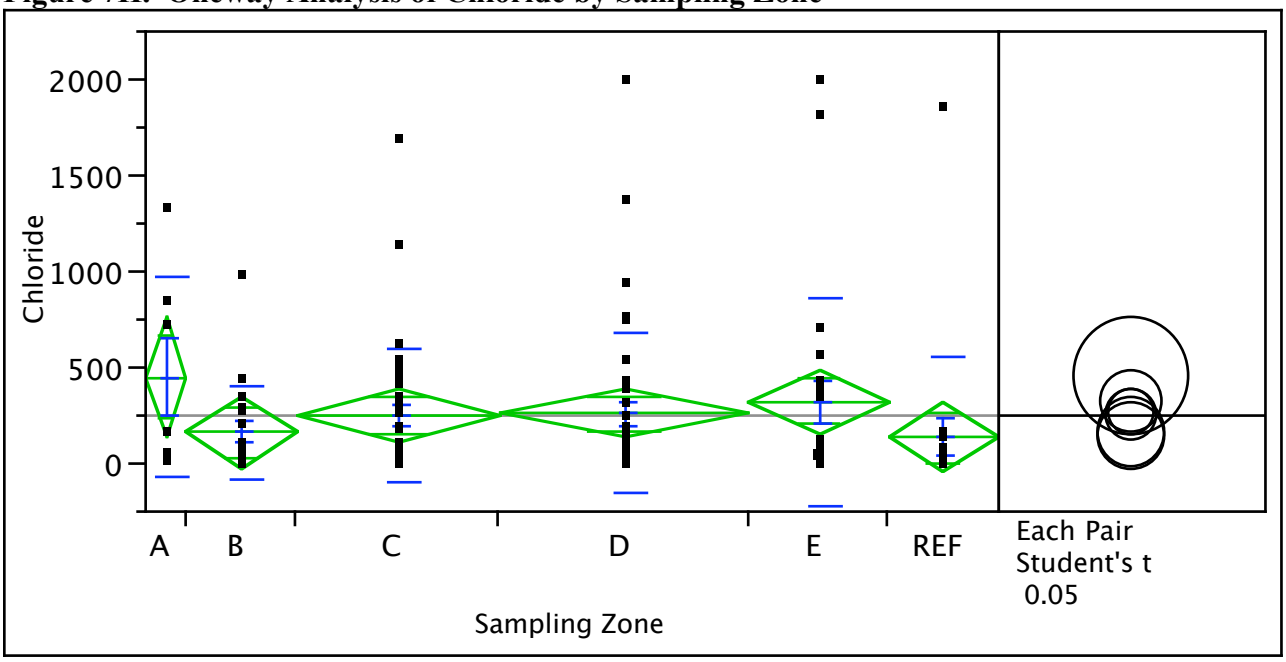
Comparisons for each pair using Student's t

t	Alpha
1.97612	0.05

Level				Mean
A	A			1049.4000
C	A	B		657.6083
B		B	C	571.9000
D		B	C	496.2933
E		B	C	440.0037
REF			C	273.3250

Levels not connected by same letter are significantly different

Figure 7H. Oneway Analysis of Chloride by Sampling Zone



Missing Rows = 7

Summary of Fit

Rsquare	0.032277
Adj Rsquare	-0.00204
Root Mean Square Error	411.5214
Mean of Response	248.7154
Observations (or Sum Wgts)	147

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sampling Zone	5	796425	159285	0.9406	0.4568
Error	141	23878336	169350		
C. Total	146	24674761			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
A	7	450.029	518.559	196.00	-29.6	929.62
B	19	160.206	242.216	55.57	43.5	276.95
C	35	252.538	351.336	59.39	131.9	373.23
D	43	260.235	413.818	63.11	132.9	387.59
E	24	321.233	538.328	109.89	93.9	548.55
REF	19	138.342	418.623	96.04	-63.4	340.11

Comparisons for each pair using Student's t

t	Alpha
1.97693	0.05

Level		Mean
A	A	450.02857
E	A	321.23333
D	A	260.23488
C	A	252.53829
B	A	160.20632
REF	A	138.34211

Levels not connected by same letter are significantly different

APPENDIX: UNDERSTANDING JMP™ STATISTICAL GRAPHICAL RESULTS

JMP™, a product of SAS Institute, Inc., promotes itself as "The Statistical Discovery Software." It provides convenient and powerful tools to help facilitate interpretation and understanding of statistical analyses and output. As explained in JMP™'s ***Statistics and Graphics Guide***, graphical presentations produced in the analytical process help us to understand the results through visual representations. From the chapter entitled ***One-Way ANOVA***, here are some simple explanations and guidelines for interpreting many of the plots presented in this report:

1. Each point plotted on the Y-axis for concentration is actually the ***mean*** calculated for replicate samples analyzed for each location plotted on the X-axis.

   The standard ANOVA can also perform multiple comparison tests and visually represent these comparisons. The test used here is Student's *t*-test, which was determined appropriate given the factors contributing to data variability in this study. An alpha-level ($\alpha = 0.05$) was used throughout these analyses.

2. Since only the *y* variable is continuous, JMP™'s one-way ANOVAs produce plots with means diamonds and comparison circles instead of continuous lines or scatterplots.

   - Each plot of means diamonds shows:
     - the overall grand mean across the middle; and
     - data points above each group along the X-axis.
   - Each means diamond illustrates:
     - its group mean across its center;
     - the 95% confidence interval (C.I.) associated with this mean, as shown by the diamond's height; and
     - the sample size of each *x* variable, because the width of each diamond along the *x*-axis is proportional (narrower diamonds are usually taller because fewer data points yield a less precise estimate of the group mean).

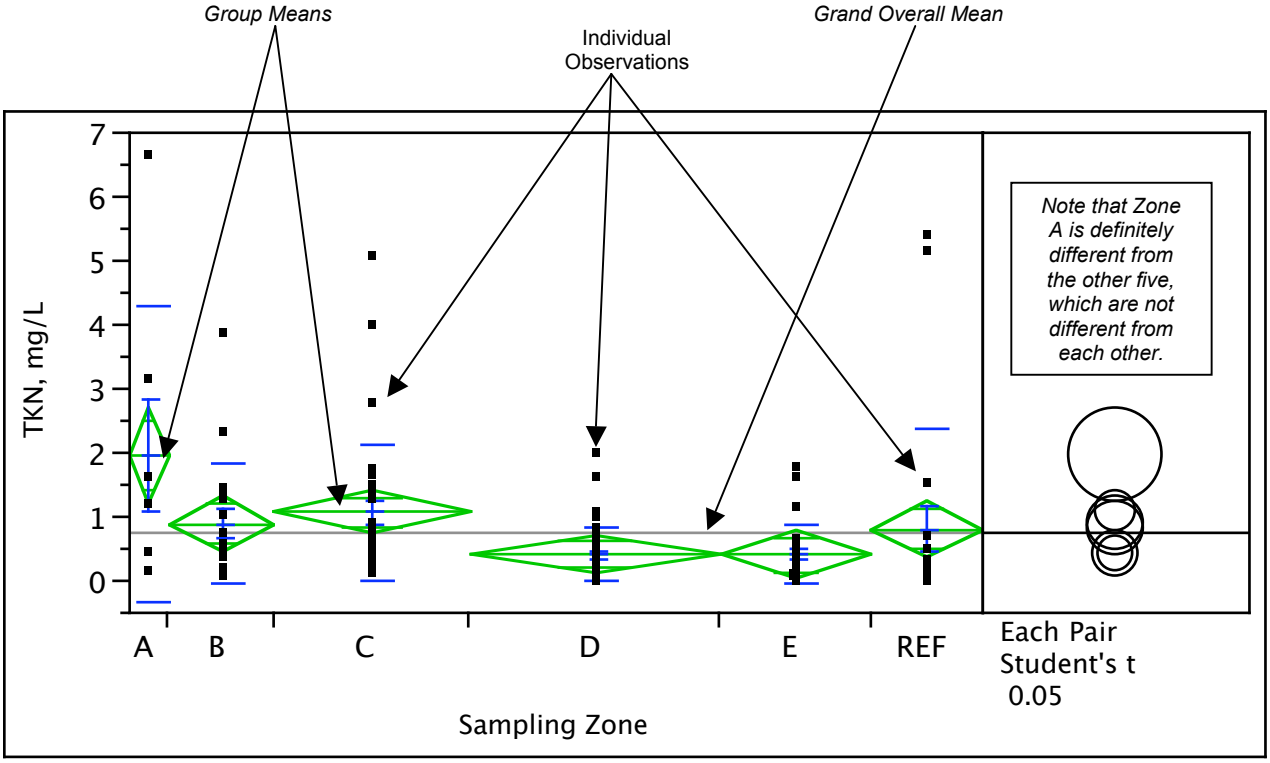
   One can compare each pair of group means visually by examining how the accompanying comparison circles intersect. The outside angle of intersection tells whether group means are significantly different at the 95% C.I.:

   - Circles for means that are significantly different either do not intersect or intersect slightly so that the outside angle of intersection is less than 90 degrees.
   - If the circles intersect by an angle of more than 90 degrees, or if they are nested, the means are not significantly different.
   - The 95% C.I. determines circle size; smaller circles represent less data variability and more precise estimates of means, whereas larger circles indicate more variability.

   Figure 7B (Oneway Analysis of TKN by Sampling Zone) provides a good example of means

diamonds and comparison circles:

Height of each diamond and size of each circle signifies 95% CI, and is a function of variability in the data set. For example, the flatness of Sampling Zone D's diamond and its corresponding small circle indicate that mean TKN level at that distance is significantly less than at Zone A, with relatively little variability. The taller Sampling Zone A diamond indicates greater variability.



Width of diamond represents relative number of samples: for example, Sampling Zone A had fewer than Zones C and D.